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ORIGINAL ARTICLES.

ON RADIANT LIGHT AND HEAT.

By Balfour Stewart, M.A., F.R.S.

While the progress of knowledge more and more reveals the intimate relationship which subsists between different truths, it may nevertheless be sometimes expedient to set apart for separate consideration some field of science possessing a boundary line which is perfectly natural and definite. The subject of our choice has this advantage. We all know that heated bodies give out a species of influence capable of traversing space with enormous velocity, and in virtue of which the eye is enabled to perceive the sun and stars. Science further informs us, that such bodies emit also non-luminous rays, some of which have a chemical virtue, and all, including also the luminous ones, have the power of heating those substances upon which they fall and whereby they are absorbed.

The remarks we are now about to make are capable of extension to the whole of this complex radiation, but we have preferred to embrace them under the term Radiant Light and Heat,—a title which, although not complete, yet recalls those properties of rays with which we are most familiar.

Our limited space will not, however, permit of our discussing more than one of the many interesting problems presented by this subject for our consideration.

An idea very generally adopted until lately, was that which regards a luminous body as discharging through space innumerable particles of exceedingly small magnitude with the almost incredible velocity of nearly 200,000 miles per second. But objections of a very formidable nature have gradually gathered around this view, until it has been generally abandoned, and light is now rather considered as an undulation which is propagated in all directions from a luminous centre, through some very attenuated medium pervading space. Accepting this view of the case, let us now briefly inquire into the nature of these waves,

ascertaining also how this is modified by the various qualities of those bodies which give rise to luminous rays, as well as by the qualities of those other bodies whereon they fall.

If we fasten one end of a long cord to a peg, and holding the other end not too tightly in the hand, then strike the cord with a rod, we shall perceive that the blow causes an agitation, which travels along the cord with a progressive motion. We shall also at once comprehend that this *something* which travels is not a substance but a form, and that it is similar in this respect to that appearance which sweeps across a field of corn on a windy day. Our readers will obtain a very good idea of the undulations which constitute light, if they suppose them similar to the waves that travel along such a cord.

So much for the nature of the light-waves; let us now consider their length. Wave-length, or the distance between the crest of one wave and that of its neighbour, is a term which explains itself. Anyone who has witnessed the phenomena of the ocean, or even of a pool of water, can have no difficulty in comprehending what this means. If a stone be dropped into a pond, the space between two consecutive circles of agitation affords a measure of the wave-length, which is, however, very small as compared with the distance between two great ocean waves. In the theory of sound the wave-length is an important element, and determines the pitch of the note; the rule being, that by descending one octave you double the wave-length. Now, what have we in optics analogous to pitch in a musical note?

Colour will at once be recognized; and we shall all be prepared to find that the wave-length of a ray of light determines its colour, and that red, orange, yellow, green, blue, violet, &c., have each their appropriate wave-length. We need hardly remind our readers that a ray of sunlight contains, blended together, not one but many of these wave-lengths; for we all know that many colours go to form white, and we are no doubt familiar with the method by which a ray of white light may be decomposed into its many-coloured components. Nevertheless, as this is a subject of very great importance in the present inquiry, we may be allowed to discuss it at some length. Newton was the first to show that a ray of white light is, in reality, compound, and his fundamental experiment may be thus described. Let us take a glass prism, and place it in a vertical position.

Fig. 1.

Fig. 2.

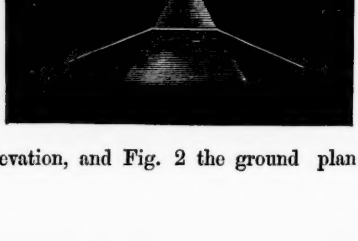


Fig. 1 represents an elevation, and Fig. 2 the ground plan of

such an arrangement. Now, let a ray of light, as in Fig. 2, strike obliquely against the side of the prism, enter it, and pass through. It will be greatly deflected by this process, so that its line of exit will differ very much in direction from that of incidence. This is sufficiently well shown in our figure, but there is yet something more. All rays are bent, but rays of one colour are deflected differently from those of another. If, now, the ray which impinges upon the prism be a single one of white light, that which leaves it will be no longer a single ray, but rather a pencil of rays, in which we shall obtain, in a separated condition, all those colours which together constitute white, because each one has been bent in a different direction.

We may now easily comprehend what is meant in optics by the term "Spectrum." In order to do so let us recall before us the ordinary photographic camera, not however to be used in obtaining the likeness of a landscape or of a friend's face, but only that of a slit illuminated by white light. If our arrangement be the ordinary one, we shall of course obtain as an image on the screen which is placed in the focus of the camera a single line of light; but if we interpose a glass prism between the illuminated slit and its image, each individual colour which goes to form white light will be bent in a different direction by this prism, and will give rise to an image that will be thrown upon a different part of the screen. Instead therefore of having one image of the slit of light upon the screen, we shall in reality obtain a number, each having its appropriate colour. The image will, in truth, form not a line at all, but rather an oblong space differently coloured at each part. This oblong illuminated coloured space is called a "spectrum;" and if the line of light whose image we are viewing be that which proceeds from a slit illuminated by the sun, then we shall obtain the solar spectrum.

Let us arrange so that those rays which are least bent may lie to the left, and those most bent to the right, and we shall then have colours proceeding in the following order from left to right: *viz.* red, orange, yellow, green, blue, indigo, violet. Red therefore is the least, and violet the most, refrangible ray; but at the same time the wave-length is greatest towards the left, that of red being about $\frac{1}{37000}$, while that of violet is only $\frac{1}{64000}$ of an inch. We thus see that light-waves are extremely small as compared with those of sound, and also that there is hardly one octave comprehended in the visible spectrum, since the wave-length of violet is rather more than half that of red.

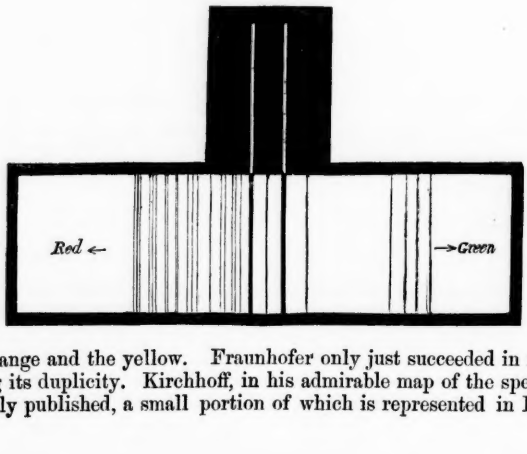
But while this embraces the whole of the visible solar spectrum, we yet know by means of the thermometer that there is a very considerable heating effect to the left of the red, thus denoting the presence of invisible rays; and we likewise know, through certain experiments which we cannot here detail, that the spectrum extends very much to the right of the violet, the invisible region in this direction being chemically powerful although its heating effect is but small. We now come to a very curious fact, first pointed out by our countryman Wollaston and afterwards by Fraunhofer. It is found that the solar

spectrum does not contain every possible ray, from the red at the one end to the violet at the other, but that the appearance it presents is that of a luminous ground crossed by black lines, which denote the absence of certain rays.

The origin of these lines was for a long time a most perplexing question. Sir David Brewster was the first who prepared the way for its solution, by showing that analogous (not identical) lines might be artificially produced by interposing a jar containing nitrous acid gas in the path of the ray. His inference was that the solar lines do not denote rays originally wanting in the light of the sun, but are due rather to the absorption produced by some substance interposed between the source of light and the spectator. His subsequent researches in conjunction with those of Dr. Gladstone and others led, on the whole, to the belief that this absorption was probably not due to the earth's atmosphere, and of course the only remaining field for such an influence was the atmosphere of the sun. But it remained for Kirchhoff, a distinguished German philosopher, to set the matter at rest, not however before the true explanation had been divined by Professor Stokes. This belongs to another part of our subject: in the meantime we shall describe what has been already accomplished in delineating these wonderful phenomena, the lines.

In the solar spectrum, as in the starry firmament, every new accession of magnifying power enables us to reap a fresh harvest of discovery. Thick lines split themselves up into a bundle of thin ones; nebulous bands resolve themselves into distinct lines; new groups spring into existence, and the appearance of things is so entirely altered, that an observer accustomed to a small instrument would not be able to recognize those very parts of the spectrum with which he used to be most familiar. This cannot be better exemplified than by referring to the double line known as "D," a prominent line between

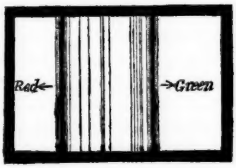
FIG. 3.



the orange and the yellow. Fraunhofer only just succeeded in recognizing its duplicity. Kirchhoff, in his admirable map of the spectrum recently published, a small portion of which is represented in Fig. 3,

has drawn it as the two strong lines with a faint one between, shown in our cut. Professor Cooke, of America, has still further filled up the intervening space, while very lately Mr. Gassiot, by his magnificent spectroscope of eleven sulphuret of carbon prisms, has obtained the appearance presented in Fig. 4.

FIG. 4.



In order to give our readers an idea of the amount of separation between the different kinds of light produced by the prism, we may mention that Kirchhoff lengthens out the visible spectrum into 8 feet, while a map is being prepared at Kew Observatory from Mr. Gassiot's spectroscope, which, when finished, will probably attain the very great length of 24 feet. But even with instruments of the highest power, we yet perceive nebulous bands in the spectrum, which a still higher power might not improbably resolve into lines; just as with Lord Rosse's telescope we observe nebulæ in the heavens which a higher power might possibly resolve into stars.

Spectra of the fixed stars have likewise been obtained by several observers. Fraunhofer noticed that the double line D was present in some of these. Secchi, Airy, and others, and more lately Huggins and Miller, have obtained the spectra of several stars. The last-mentioned observers, in particular, have furnished detailed maps of those of Aldebaran, Alpha Orionis, and Beta Pegasi. We shall return again to this subject, but in the meantime we may remark that the general character of stellar spectra is a luminous ground intersected by dark lines, many of which are identical with lines in the solar spectrum, while others however are different.

But we must not omit to mention the appearance presented by the spectra of heated vapours. Electricity and other agents enable us to obtain the vapours of metals and other bodies at an extremely high temperature, and when the rays which these emit are analyzed by the prism in the way already mentioned, we have results which are exceedingly curious. The metal sodium, or any of its compounds, such as common salt, produces a flame which is intensely yellow; and this flame, when analyzed by the prism, is found to consist of two simple rays exactly corresponding in position with the two lines D. We are thus furnished in the salt flame with two rays which are absent in the light of the sun, and with these rays alone, for there is not a vestige of any other, and we have a perfectly dark ground—the appearance being that of the upper portion of Fig. 3. Again, when the vapour which we examine is that of iron, we have as before bright lines on a dark ground, and these have been found by Kirchhoff to coincide with certain dark lines in the solar spectrum. Generally speaking, all heated vapours give spectra, consisting of bright lines scattered over a dark space, but in many of these the bright lines have not as yet been found to coincide with dark solar lines. It has been shown by Bunsen, Kirchhoff, and others, that these bright lines are always characteristic of the vapour which is ignited to produce them. Each ele-

mentary substance has its peculiar lines, and probably no line of any one element is exactly coincident with that of any other. We are thus furnished in the spectroscope with an exceedingly delicate test of the presence of any substance. We have only to pass the electric spark through the body which we wish to analyze, and the sudden flash perceived is in reality a small portion of the vapour of that body in a state of intense ignition. If we analyze this by the spectroscope, we shall obtain lines that will enable us to determine the substance employed. So delicate is this method, that we can detect with ease the presence of quantities of a sodium salt less than $\frac{1}{200,000,000}$ of a grain in weight. Nor is it valuable only for substances with which we are familiar, but it has also been the means of our discovering new elements. The metals Cæsium and Rubidium were thus discovered by Bunsen; Thallium, by our countryman Crookes; and Indium, by Messrs. Reich and Richter.

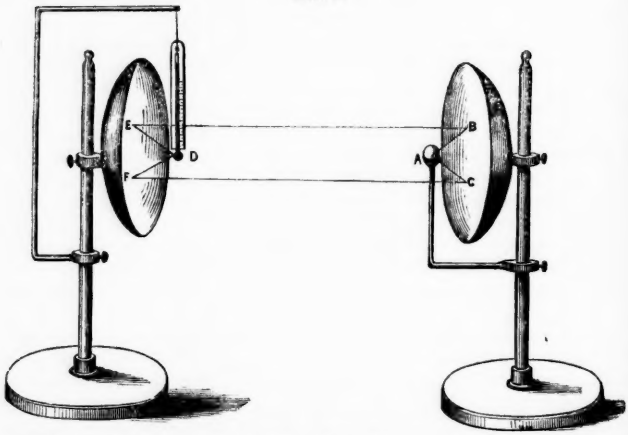
So much for ignited vapours. On the other hand, the spectra of incandescent opaque solid or liquid bodies, or of all bodies of very great thickness, are continuous throughout, and consist of a bright space, varying in colour from one portion to another, but without lines. We have thus three varieties of spectra.

First. Solar and stellar spectra, exhibiting a bright ground interspersed with dark lines.

Secondly. Those of heated vapours, consisting of bright lines on a dark ground.

Thirdly. Those of opaque, solid, and liquid bodies, consisting of a continuous brightness without lines.

Fig. 5.



We must now request our readers to accompany us to quite a different part of our subject, although in the end we hope to trace its connection with that which has preceded.

Towards the latter part of last century Professor Pictet, of Geneva, performed a curious experiment which appeared to prove the reflexion of cold. He placed two polished metallic concave reflectors facing one another, as in Figure 5, and while in the focus of the one he put a thermometer, in that of the other he placed a lump of ice, the effect of which was to lower the temperature of the thermometer. At first sight this result would seem to indicate that cold is something more than a mere negation, and indeed that it is an influence susceptible of radiation and reflexion in the same manner as heat. It soon, however, occurred to Professor Pierre Prevost, of Geneva, that this was by no means a necessary conclusion, and this sagacious reasoner proposed, as an explanation of the experiment, the theory of Exchanges, or, as he termed it, a movable equilibrium. In order to comprehend this definition, let us suppose that we have a room walled in on every side, and that its walls, including the floor and ceiling, have the temperature of 60° Fahrenheit. Now in whatever part of such a room a thermometer is placed, it will ultimately attain the temperature of the walls; that is to say, it will indicate 60° Fahrenheit, after which the mercury will neither rise nor fall, and there will be an equilibrium of temperature. When this has happened one of two things must be taking place. Either the thermometer does not give out radiant heat, or if it does it receives back continually just as much as it gives out. Prevost supposes the latter to be the case, and that all bodies even of the same temperature are continually giving out heat to one another, and receiving in return just as much as they give out. Therefore, according to his theory, a body will fall in temperature when it radiates or gives out more heat than it absorbs, its temperature will be constant when the radiation and absorption are equal, and will rise when the absorption is greater than the radiation.

Let us now see how this idea will explain Pictet's experiments. By this theory, although the bulb D is of the same temperature as the reflector E F, yet there is a constant interchange of heat between them. Hence rays of heat will leave the bulb in the direction D E and D F, and these will finally be reflected upon A. The body A is however giving out rays in return, which finally fall upon D. But since A is colder than D, the rays which leave D and fall upon A are more intense than those which leave A and fall upon D. The consequence of this will be that on the whole there will be a transference of heat from D to A, and the temperature of the thermometer will fall. And this transference from D to A will be just as much intensified by the reflectors as that from A to D would have been had A been hotter instead of colder than D.

Thus we see how easily the observation of Pictet is accounted for by the principle of exchanges—a principle which soon exhibited all the marks of a true theory by explaining facts as they were elicited by experiment, and at the same time by suggesting new truths, in which latter aspect more especially it has been of very signal service to science. But it is not our intention to give the history of this problem; let us rather remark its more interesting and important applications. Let us for this purpose imagine a red-hot chamber having the tem-

perature of 1,000° Fahrenheit, the sides of which are composed of every variety of substance from polished metal to lamp-black. Let us place in this room a suitable instrument for measuring temperature —call it a thermometer—it is clear that in whatever part of the room we place this instrument it will always denote 1,000°, since all the walls are of that temperature. Let us bring our thermometer near to the polished metal, it will still denote 1,000°. Now the rays which reach the thermometer from the polished metal are twofold. First, there are those given out by the metal itself since it is red hot; and secondly, there are those which it reflects from the lamp-black surface beside it. But this twofold supply of heat from the polished metal, partly given out and partly reflected, will be *too much* for the thermometer, unless it happens that the metal, in virtue of the heat which it reflects, gives out so much less on its own account. This is found to be the case, and it is very easy to convince ourselves by experiment that a reflecting body when heated gives out little light. Let us take a piece of platinum, partly polished and partly tarnished, heat it to a white heat and then immediately examine it in the dark. We shall find that the polished portion is much less luminous than the tarnished. Or, in like manner, let us heat some lead or tin to a good red heat, and then take the vessel containing it into the dark; if we skim its surface with a red-hot iron spoon we shall find that the heated metal underneath is much less luminous than the dross. We may vary the experiment by heating a piece of porcelain of a black and white pattern, and examining it in the same manner, when we shall find that the black is much more luminous than the white, the reversal of the pattern producing a very curious effect.

But let us return again to our chamber, and now suspend in a vertical position, near one of the walls, a sheet of transparent colourless glass, leaving it, of course, for a sufficient length of time to enable it to acquire the temperature of the chamber. Let us place our thermometer in front of this plate. Now, the plate being transparent will permit to pass through its substance all the red heat from the wall behind it: if, in addition to this, it gave out a great deal on its own account, we should have, just as in the previous case, a twofold supply of heat falling upon the thermometer, so that its temperature would rise above that of the chamber. Since this cannot be the case, it follows that transparent glass will give out very little red light on its own account when heated to redness. We may verify this for ourselves by taking various pieces of glass, some colourless, and others more or less coloured; let us heat them to a good red heat, and examine them in the dark. It will then be found that a colourless piece gives out very little light, while a highly-coloured or opaque specimen gives out very much. The law may be stated thus:— a body which absorbs much heat will also give out much on its own account when heated.

But one important fact yet remains behind. Let us revert to the plate of glass suspended in the red-hot chamber, and suppose this plate to be of such a colour as to stop all the red rays that reach it from the wall behind. We have already seen that, if it stops a good

many rays, it will give out a good many. We have further to observe, that the rays it gives out must be precisely of the same kind as those which it arrests: it stops the red rays. Now, if it give out dark heat, but not red, then, looking towards the glass, we shall get no light from it, since it stops the red rays from behind, and gives out none of its own. But this is evidently impossible in a red-hot chamber, for universal experience teaches us, that any substance left in such a chamber will ultimately appear red hot. If, therefore, the glass be of such a nature as to stop any particular ray of light or heat, it will, when at a high temperature, give out on its own account that very ray. This may be exemplified by several very simple experiments. Take a piece of ruby glass, coloured with gold. This glass, as its name sufficiently denotes, allows all the red rays to pass, but stops the green. Heat it in the fire to a good heat, and examine it in the dark, when it will be found to give out greenish rays. On the other hand, green glass (which stops red rays) will, when heated, give out a dark-red light. These curious facts may be noticed at any place where coloured glasses are spun. Another good illustration of this law is obtained by putting a number of differently-coloured glasses into the fire, and it will be found that they all appear to lose their colour when they become of the same temperature as the coals around them. Not that the glasses have changed their nature in the least, for the red glass still stops the green, and the green glass the red rays, from the coals behind; but each glass gives out, on its own account, precisely those rays which it stops, so that the light (transmitted and radiated together) which comes from the glass is just the same as would have come from the coals alone.

Kirchhoff has beautifully extended this law to those individual rays which compose the spectra of luminous bodies. We have already stated that the spectrum of sodium consists of two bright lines D, and in general that the spectrum of a heated vapour consists of bright lines on a dark ground. Now, if instead of using these vapours as our source of heat, we use them in a comparatively cold state as a screen, our source being an incandescent solid body which gives out all rays, then we shall find that each vapour stops precisely those rays which it gives out when heated. Thus, a salt flame, or incandescent sodium, gives out the double line D; vapour of sodium (when cold) also stops the same line, and a similar rule holds for all vapours. Whenever, therefore, we have a source of light containing all rays, but which is surrounded by an atmosphere of metallic vapours at a low temperature, each of these vapours will stop its own appropriate rays, and the spectrum of such a system will exhibit a bright ground intersected by dark lines. This is precisely the character of the solar spectrum, and we have seen that one of its lines, namely D, is that which is produced by the absorptive power of sodium vapour. We are therefore entitled to conclude that this vapour exists in the atmosphere of the sun. Again, the vapour of iron gives out certain bright lines which appear as dark in the sun's spectrum, we conclude therefore that iron vapour exists there in a *comparatively* cold state; and in like manner we find that a number of the solar lines are due to

the presence of nickel, and that calcium, magnesium, barium, copper, zinc, all well-known substances, are suspended in the atmosphere of our luminary. By a similar process, sodium, magnesium, hydrogen, calcium, iron, bismuth, tellurium, antimony, and mercury, have been found in Aldebaran, and other elements in other stars.

We have thus arrived at the wonderful result that many of these substances with which we are most familiar occur also in the sun and stars, and the great law which has led us to this conclusion may be stated thus:—a body absorbs those very rays which it gives out when heated. Let us now see if we have not a similar law in other branches of science. When a musical note is sounded in the presence of a string which would give out the same note, the string catches up or absorbs the musical note in order to give it out on its own account. We may place the two laws side by side in the following manner.

A body when cold absorbs the ray which it emits when heated. A string when at rest catches up the note which it gives out when struck. Nor perhaps are we without an indication that the same law holds in medicine. *Similia similibus curantur* (like cures like) is the doctrine of a certain school; but we leave homœopathists to follow out the analogy here suggested.

We have offered these observations in order to show our readers that the law which we have endeavoured to place before them is one whose foundation lies very deep in the present system of things: and the result that Kirchhoff has deduced from this law is one altogether worthy of its greatness; a result bringing vividly before us the *oneness* of the universe, inasmuch as it discloses the prevalence throughout the solar and stellar systems of those very forms and species of matter with which we are here familiar. No fact hitherto discovered so much exhibits the unity of creation—none more the unity of the Creator; and thus the last great achievement of science becomes as it were a comment on the first page of Sacred History, in which we are told that "He made the stars also."

ON THE SOURCE OF LIVING ORGANISMS.

By James Samuelson, Editor.

There are two subjects in Natural History which, more than any other, attract the attention of modern biologists,—the Origin of Species, and the Source from which the lowest known Forms of Life are derived; in other words (reversing the order of subjects), the Beginning of Life, and its Continuance.

To those persons who have followed the discussions relative to these two inquiries, it is quite obvious why they should simultaneously occupy the attention of the scientific world, for it has with truth been observed, that an earnest advocate of the Darwinian theory, one who teaches that every living form is and has been the result of a modifi-

cation of some lower and preceding form of life, brought about solely by secondary causes, cannot halt midway in his teaching, and be content to hold that life began with four or five primitive types, such as he may be able to trace in the lowest inhabited strata; he must carry his investigations still further, and must account satisfactorily for the appearance of life-endowed beings in any shape, before he can be said to have fully established his position.

It is in this spirit that the inquiry is now prosecuted; and those who take a deep interest in the subject, do so, not as formerly, for the purpose of ascertaining from what source a particular group or species of animals is derived, but with an earnest desire to obtain some knowledge as to the conditions under which life is first manifested on the earth's surface. Nor is the consideration of the subject confined to the ranks of biologists only, for some of the most important discoveries have already been made by chemists and physicists, and it is more than probable that the solution of the problem (should that follow in the course of time) will be due to the joint researches of men engaged in the study of these various branches of science, every one of which cannot fail to be indirectly benefited by the investigation.

Probably the attention of reflecting observers was first directed to the subject of the origin of living beings through the mysterious appearance, in the decaying bodies of animals and elsewhere, of the larvæ of insects; and the earliest treatise of any note on the subject was most likely that of Redi, 'De Generatione Insectorum,' Amsterdam, 1686, up to whose time it was currently believed that decaying substances became converted, during their decomposition, into insects and some other forms ranking below them in the animal scale. This is called "spontaneous generation."

After the publication of Redi's researches on the mode of reproduction in insects, the theory of abnormal generation was for a time discarded; but about sixty years subsequently, in 1745, Needham revived it in a work published in London, entitled 'New Microscopical Discoveries;' and, on the other hand, about fifty years after that, another observer, Spallanzani, an Italian, attempted to disprove the existence of "spontaneous generation" by experiments and philosophical induction. He sought to show that animalculæ which make their appearance in decaying organic substances are not accidentally generated by the reconstruction and reorganization of such matters, but that their ova, or germs, exist in the atmosphere, and being conveyed into the decaying substances, find in them a suitable pabulum, and thus become developed. He stated that if the air is excluded from such substances no animalculæ make their appearance.

This was the state of the discussion sixty or seventy years since; and although considerable progress has no doubt been made in the inquiry, the field of research being necessarily more restricted than formerly, inasmuch as every day the appearance of some form or other is accounted for without any appeal to "spontaneous generation," still the elements of the dispute remain much the same as they were, and the chief efforts of investigators are directed to the proof or

disproof of the existence of the germs of living beings in the atmosphere.

The clearest and most tangible exposition of the views of those who formerly advocated the theory of heterogenesis, or abnormal generation, is to be found in Todd and Bowman's 'Cyclopædia of Physiology,' in the edition published in 1839;* and it will be found useful for our purpose to extract some of the writer's remarks, inasmuch as they will show the student of to-day how the recent revelations of science have struck away, one by one, the props upon which the doctrine was based, and have so reduced the inquiry within the narrowest limits.

"The following considerations appear to us to throw the balance of evidence in favour of the spontaneous production of infusoria, mould, and the like. Firstly, those organic matters which are most soluble in water, and at the same time most prone to decomposition, give rise to the greatest quantity of animalcules or cryptogamic plants. Secondly, the nature of the animalcule or vegetable production bears a constant relation to the state of the infusion; so that, in similar circumstances, the same are always produced without this being influenced by the atmosphere. There seems also to be a certain progressive advance in the productive powers of the infusion, for at first the animalcules are only of the smallest kinds, or monads, and afterwards they become gradually larger and more complicated in their structure: after a time the production ceases, although the materials are by no means exhausted. When the quantity of water is very small, and the organic matter abundant, the production is usually of a vegetable nature; when there is much water, animalcules are more frequently produced. Thirdly, on the supposition that infusory animalcules are developed from ova, it is necessary to conclude, from the experiments already referred to, that these ova are in some instances derived from the atmosphere; but yet the number of infusoria is by no means in proportion with the quantity of air. We are also reduced to the necessity of holding that every portion of the atmospheric air is equally impregnated with infusorial germs or ova, and that these bodies may remain for years dissolved, as it were, or invisibly suspended in the atmosphere, and in a perfectly dry state,—a supposition contrary to analogy, and not fully warranted by the fact that vibriones may be resuscitated by means of moisture after they have been kept in a dry state for long periods. Fourthly, it may be remarked that the existence of ova, as belonging to many of the infusoria, is entirely hypothetical, since most of these animals are known, when once formed, to propagate by other means, as by the division of their whole bodies, or by budding."

If the writer of these remarks had been aware when he penned them (and we hope he still lives to witness the results of scientific progress since his observations were made), that the same general laws which regulate the growth and development of the higher animals are found to operate very low down in the scale, he would not have leaped to such conclusions. The rapid increase of animalcules in substances "most prone to decomposition," would merely have satisfied him that the abundance or scarcity of living forms in infusions was

* In which the student will also find additional information concerning the history of the controversy.

in proportion to the amount of nourishment afforded to them; and in the appearance of certain characteristic types in particular infusions, he would have recognized the operation of the law which causes every plant (speaking in general terms) to be peopled by its appropriate parasite. His statement that the same animalculæ are always found in similar infusions, is however only partially correct, and, as it will be shown hereafter, is far from being a correct phenomenon.

Next, as regards the "progressive advance in the productive powers of the infusion," the appearance in fact of successive generations of living forms rising in the developmental scale, in one and the same infusion. An acquaintance with the phenomena of the "alternation of generations," and a little reflection upon the fact that "Monads" may grow into ciliated infusoria whilst the eye of the observer is engaged otherwise than in their examination, would have materially shaken the writer's faith in the "productive powers" of the infusion.

The researches of my esteemed coadjutor, Dr. Balbiani, of Paris, have set at rest the question of the existence of ova in the infusoria, for he has shown that in addition to the other processes by which they multiply, these forms possess also the sexual elements common to all animals.*

The only question, therefore, of any importance to which a satisfactory reply is required, is the one already referred to:—Do the germs of infusoria, or do they not, exist in the atmosphere in sufficient quantities to account for their entrance into infusions?

Before proceeding to consider this vital question, however, it is right that I should touch upon a phenomenon referred to by the writer in "Bowman" in another part of his article, and thrown by him into the scale in favour of the theory of heterogenesis. That is, the appearance of entozoa, or internal parasites, in the tissues (or, as he says, the bodies) of living animals. This is really a most difficult problem to solve, but we never hear it mentioned at the present day even by the advocates of heterogenesis. The presence of some of these parasites is still a great mystery, on which a partial light only has been thrown by the recent researches of zoologists in regard to the transformations that such forms undergo in their passage from one animal into another, from the prey into the stomach, and then into the vascular, or other systems of its devourer. As already observed, the advocates of the doctrine under consideration do not now affirm that any of these forms are spontaneously produced from the living tissues in which they are found; and I believe that at no very distant period their presence will be, in all cases, fully accounted for.

The chief investigators who have recently asserted that the germs of living beings do *not* exist in the atmosphere, or that they exist only in such small quantities as to render it impossible that the swarms of animalculæ which appear in infusions should be derived from that source, are—Messieurs. Pouchet, Jolly, and Musset (France); Dr. Jeffries Wyman, of Boston (America); Schaffhausen

* 'Recherches sur les Phénomènes sexuels des Infusoires,' par le Docteur A. Balbiani. Paris: Masson. 1863.

(Germany); and Mantegazza (Italy); whilst amongst those who maintain that the atmosphere is the chief source from which such forms spring, are—Schultze and Schwann, and Schrœder (Germany); Pasteur and Quatrefages (France); and there are many other biologists of note who accept the latter view, but whose conclusions are based rather upon induction than experiment.

Taking first the views of the believers in heterogenesis, we have those of Dr. Pouchet, of Rouen, whose investigations, it cannot be denied, have been very elaborate and persevering. He finds in the dust of the air, "the detritus of the mineral crust of the earth, animal and vegetable particles, and the minutely divided débris of the various articles employed in our wants;" but he says (after narrating what kind of animal *remains* he has found, these being unimportant in our inquiry), "twice only in more than a thousand observations, have I observed one of those large ova of infusoria having a diameter of 0,0150 m.m., denominated by naturalists 'cysts.'"* Amongst the numerous experiments tried by Dr. Pouchet, in order to satisfy himself that the "ova" of infusoria do not exist in the atmosphere, is the following:†—

"By means of an inhaling flask, I caused 100 litres of air to pass through a safety tube, whose bulb contained two cubic centimetres of distilled water. At the end of eight days I was unable to discover a single animalcule or ovum in this small quantity of water, in which the latter themselves could not escape observation, now that they have been completely described and measured, and are well known in several species.‡ On the contrary, if I place in a cubic decimetre of distilled water five grammes of fermentable substance, sheltered by a bell glass having a capacity of one litre, at the end of eight days, and at a temperature of 18° C, the whole surface of the water is occupied by incalculable myriads of animalcules."

It would be impossible to follow Dr. Pouchet through his experiments, all of which lead him to the conclusion that "spontaneous generation" is the sufficient and sole explanation of the appearance of Protozoa in infusions; suffice it to say that he has examined the air of towns and of mountain heights, the dust from ancient temples and subterranean sepulchres, and nowhere has it yielded him the slightest evidence of "panspermie;" the universal diffusion of living germs.

Of Messieurs Jolly and Musset it is only necessary to say, that they have recently been the coadjutors of Dr. Pouchet, and that they testify fully to the accuracy of his statements.§

Leaving for a time the ranks of the champions of "spontaneous

* 'Comptes Rendus,' March 21, 1859: translated in the 'Microscopical Journal,' 1860, p. 130.

† *Loc. cit.* p. 134.

‡ I presume Dr. Pouchet refers to "cysts," for Balbiani's discoveries were not published until two years afterwards.

§ They also tried some independent experiments, which will be found described in the 'Microscopical Journal,' new series (1861), p. 47, to prove that "spontaneous generation" may take place in the infusions inserted in the cavities of fruits. I must leave the consideration of these to scientific judges, but do not deem them sufficiently important for transcription here.

generation," we shall now enter those of its opponents, and briefly consider their investigations.

In the year 1837 two German observers, Schultze and Schwann, endeavoured to show that the germs of infusoria *do* exist in the atmosphere, and that when means are taken to destroy these germs before the air in which they are suspended reaches the infusion, no animalculæ appear in it, even after a lapse of some weeks. By means of an apparatus consisting of a flask and tube, provided with bulbs which contained sulphuric acid and caustic potash, they submitted the air to a kind of purification (from animal germs), before allowing it to play upon the infusion; and they asserted that infusions which had been subjected to the influence of air thus treated, showed no signs of animal life even after two months' exposure, whilst others that had been freely exposed to atmospheric influences contained innumerable infusoria.

More recently, Schrœder, a German chemist, arrived at the same results by a different method, and one that appears to me to be more conclusive; inasmuch as it might be advanced by the advocates of the theory of "spontaneous generation" that the same chemical and physical agents (for in some cases the air has been heated to an extreme degree) which are said to destroy the germs of living forms in their passage to the infusion, might also render the atmosphere unfit to sustain life on any terms. Schrœder then* filtered the air by passing it through cotton wool, and found that when infusions which had been previously boiled were exposed to the atmosphere thus filtrated, no decomposition took place. This result he believed to be owing to the fact that ebullition destroys the germs which would otherwise be contained in the infusion, whilst the cotton wool prevented the access of fresh germs with the atmosphere. In this manner he accounts for the preservation of fruits, &c., which are boiled and then covered with bladder or other materials that serve to filter or exclude the air.

The experiments of this observer (which have not, I think, been sufficiently acknowledged by those who have availed themselves of his experience) I have myself repeated with scrupulous care, and the result has been that although I cannot fully confirm what he says in regard to the *entire* absence of Protozoa in infusions which have been protected by cotton wool, yet I can attest that their numbers and proportions, as compared with those in infusions freely exposed to the atmosphere, have been so insignificant as to leave me in no doubt as to the truth of the general principle which he has enunciated.

We now come to the researches of M. Pasteur, a French chemist of great celebrity, upon whose experiments such stress has been laid by certain English and French biologists, that they were regarded as having given a deathblow to the doctrine of "spontaneous generation," and to have proved beyond a doubt that the germs of protozoa are held suspended in the atmosphere.

Whilst conducting some experiments on the origin of ferments, M. Pasteur found in an infusion of yeast, "certain corpuscles, whose form, volume, and structure show that they are organized after the

* 'Annalen der Chemie und Pharmacie,' vol. cix. p. 35.

manner of the infusoria or of the spores of Mucidineæ;" * and was induced through this discovery to undertake certain experiments, one of which we find thus described in a paper read before the Academy of Sciences:†—

"In a series of flasks, containing 250 cubic centimetres, the author introduces the same putrescible liquid,‡ in quantity sufficient to occupy about a third of the total volume of the vessel. The necks of the flasks are drawn out in the spirit-lamp and the liquid is made to boil, the slender extremity of the neck being closed during ebullition. A vacuum is thus produced in the flask. He" (the experimenter) "then breaks off the points in a given locality. The air enters with violence, drawing along with it all the dusty particles it may hold in suspension, and all the principles, known or unknown, associated with it. The flask is then immediately closed with the blowpipe, and placed in a stove heated to 20° or 30° C. (70° to 85° Fahr.), that is to say, in the best condition for the development of animalcules and mucores. The results of the following experiments are not in accordance with the principles generally admitted, but they are perfectly in agreement, on the other hand, with the idea of a dissemination of germs. In most cases in a few days the liquid begins to decompose, and in the flasks, although they may be placed in identical conditions, organisms of the most varied kinds will be seen to arise, far more varied, in fact, especially as regards the Mucidineæ or Torulaceæ, than would have been produced if the liquids had been exposed to the common air. But on the other hand it often happens several times in each series of experiments, that the liquid remains absolutely unaffected, whatever may be the duration of its exposure in the stove, and just as if it had been filled with air that had been exposed to a red heat."

M. Pasteur infers from the latter fact, that it is possible to find in certain localities a given quantity of air which contains no germs;—his general conclusion being, however, as the reader will have observed, in favour of a diffusion of germs through the atmosphere. He also tried other experiments, in which various measures were adopted to intercept the germs in their passage to the infusions (on a similar principle to that employed by Schrœder), and his previous conclusions were verified by the results.§

But Pasteur's experiments, satisfactory and conclusive as they may have appeared to some naturalists, have by no means passed unchallenged. Dr. Jeffries Wyman, of Boston, repeated them, as well as those of Schulze, with, as he affirms, precisely the opposite results; and found that in cases where every precaution had been taken to *exclude* germs from his infusions, they made their appearance after a few days. The vessels were opened in the presence of Professor Asa Gray, and in them were found *chiefly* the very lowest known forms;

* 'Comptes Rendus,' May 7, 1860: translated in the 'Microscopical Journal,' 1860, p. 255.

† 'Comptes Rendus,' Sept. 3, 1860: translated in the 'Microscopical Journal,' April, 1861.

‡ Albuminous water from the yeast of beer; albuminous water containing sugar, urine, &c.

§ He even went so far as to "sow" the germs intercepted by cotton wool in infusions which had before been unproductive of infusoria, and stated that animalculæ then made their appearance.

but mention is made also of "colpoda-like bodies, having ciliary motion."

Still more recently, too, a trustworthy observer at Oxford, Dr. Gilbert W. Child, communicated to the Royal Society the account of a series of experiments, twenty in number, performed with various infusions and a great variety of gases; and although the author modestly states that no definite conclusion can be drawn from so limited a range of experiments, "it is worthy of remark," he says, "that organisms were found here under the precise circumstances in which M. Pasteur states that they cannot and do not exist;" and, he adds, that "the very abnormal conditions under which some of these so-called organisms are found, would render it doubtful whether bacteriums, vibrios, &c., ought to be considered as independent organisms in any higher sense than are white blood-corpuscles, pollen-grains, mucus-corpuscles, or spermatozoa."*

Due allowance being made for the brevity necessitated by the limited space at my command, I believe that my readers have had presented to them a faithful and unbiassed review of this controversy concerning the origin or derivation of living organisms.

A large amount of feeling has been imported into the discussion, especially amongst our esteemed neighbours across the Channel (who, it is right to add, have done the most effective work), and that is one reason why I refrain from commenting upon the evidence of each investigator.† One circumstance must, however, have struck all who

* 'Proceedings of the Royal Society,' vol. xiii. No. 65: "Experimental Researches on Spontaneous Generation."

† Since the present article was completed, I have read, and recommend for perusal, an able review of the Pouchet-Pasteur controversy, which appeared in the July number (1864) of the 'Medico-Chirurgical Review' ("Recent Researches on the Production of Infusoria").

Although the writer leans to the doctrine of heterogenesis, he has given a very impartial account of the controversy, and has narrated many detailed experiments which my limited space has compelled me to pass unnoticed.

There are, however, two points which it appears to me that the writer has not well considered in his essay. In the first place, he speaks of the formation of "spontaneous eggs," *the production of which has been observed* by Dr. Pouchet, and says that "this observation has not been controverted by the opponents of spontaneous generation;" and, secondly, he believes that the work and opinions of Dr. Pouchet, the champion of "heterogenesis," deserve more consideration than they have received here and abroad.

As regards the first, I would remind him that in another portion of his essay (p. 105) he tells us that the germs in dispute are incapable of being brought to the test of our senses; how their formation can have been observed is therefore somewhat mysterious. And this leads to the inquiry whether Pouchet's published observations have been such as to inspire confidence in their trustworthiness: I fear not. This is not the first controversy concerning the nature of the infusoria in which Dr. Pouchet has taken a prominent part; for when, some sixteen years since, the discussion between the veteran microscopist Ehrenberg and Dujardin was at its height, as to whether the so-called *polygastrica* possessed a series of distinct stomachs connected together by an intestine (as affirmed by Ehrenberg), or whether, according to Dujardin, these so-called stomachs were only "vesicles" or "vacuoles" temporarily formed in the protoplasm, and completely disconnected from one another, Dr. Pouchet stepped in between them, and with as much gravity as he now manifests in the controversy on "spontaneous generation," proceeded to decide the debate. The great

have interested themselves in the controversy, and that is, the paucity of information afforded on both sides of the debate, as to the exact nature of the forms discovered in the infusions; for, generally speaking, we hear only of vibriones, monads, bacteriums, terms (if I may venture to say so) which have no accurate scientific meaning, and which represent only moving specks of the most obscure character.

This circumstance is to be explained by the fact that the most striking experiments have been performed by persons almost entirely unacquainted with micro-zoology, or who hold exploded views on many matters connected with that branch of science.

In entering upon a brief description of my personal experiences in connection with this subject, I fear that my labours will not have been lightened by the last criticism; but however small may be the value of the evidence which will be adduced in aid of the solution of this problem, my readers may rest assured that there has been no want of care in the identification of the forms described. Again and again evidence has been rejected by me as insufficient, because the living forms under examination would not admit of accurate description, and the few isolated data which follow have been selected from a mass of notes and sketches, many of which might have been added, were it not for the imperfection of their details.

It is eight or nine years since my attention was first directed to the subject under consideration, and from that time to the present I have, year by year, conducted experiments with a view to test the validity of the doctrine of "spontaneous generation."

The conflicting evidence which was from time to time published by trustworthy and eminent investigators, and the great difficulties that had to be encountered in the shape of adverse weather, the frequent necessity to leave my work unfinished, &c., prevented me until recently from stating what had been the results of my observations; and it has only been within the last few weeks that they have been of a sufficiently positive character to justify my coming to a definite conclusion on the subject of heterogenesis, in the present signification of the term.

defect had been, according to his views, that the disputants had not observed with sufficient accuracy; and he proceeded to state, as the result of his careful investigations, that the *polygastrica* have many *bonâ-fide* stomachs; that the number and diameter of these stomachs is fixed in each fully-developed species; that they never coalesce, for it is easily perceptible that they have distinct membranes ("des parois distinctes"), and that the pretended rotation of these stomachs is an optical illusion! (Séance de l'Académie, 13 novembre, 1848: 'Comptes Rendus,' xxvii. p. 516.)

It is hardly necessary to state that nearly all these observations have since proved incorrect; and as the learned French anatomist has never acknowledged his mistakes, one of two conclusions is therefore inevitable, *viz.* that he either still unconsciously holds antiquated and inaccurate views, or that when once he has made his declaration on a biological subject, there is no great probability of his afterwards bestowing upon it an unprejudiced consideration.

As to the recent "commission" appointed by the Academy of Sciences to decide between Pouchet and Pasteur, and which ended in the premature (and it appears to me justifiable) withdrawal of Dr. Pouchet, the whole affair had too little of the air of seriousness about it to warrant its being considered in this place.

My first definite evidence was obtained about three years since, when a series of investigations were undertaken by me in conjunction with Dr. Balbiani, of Paris, to whom I have already had occasion to refer as the author of a valuable little work on the sexual phenomena of the infusoria; and it now affords me great pleasure to state that not only did he at that time render me very useful assistance, but he gave me one or two hints which led indirectly to my subsequent experiments. In July, 1862, I forwarded to Dr. Balbiani boluses of various organic substances of which I retained the counterparts, consisting of the green juice of cabbage (chlorophyll), and the juice of fresh and baked meat, variously prepared with gum-arabic, &c.; and although my zoological readers will find that it would be quite immaterial, in the form in which my experiments were conducted, whether or not the atmosphere was excluded from these substances, still I may mention, in passing, that such precautions were taken as to render it very improbable that the air should reach them until they were exposed dissolved in distilled water.

These infusions were examined by my colleague and myself, the results noted, and the contained forms delineated; but Dr. Balbiani's investigations were, in the first instance, more successful than mine, as he was favoured with a more elevated temperature.

Since then I have from time to time exposed to the action of the atmosphere the purest distilled water that I could obtain, with a view to compare the living forms, if any should be present, with those described and delineated by my coadjutor, and with any that I might observe in infusions that have been simultaneously exposed.

Let us see what has been the result:—

Amongst the illustrations first received from Dr. Balbiani was the accompanying, which represents what he called "*Cercomonas fusiformis*," found by him in great numbers in both the *animal* and *vegetable* infusions.

FIG. 1.—Cercomonas fusiformis.
(From Dr. Balbiani's original drawing.)

He designated these little forms after Dujardin, who thus figures one in his work on the Infusoria.*

Dr. Balbiani might with equal propriety have called his animalcule, *Cercomonas acuminata*, also figured in Dujardin's work, from which it differed but slightly, being, I think, the same type.

FIG. 2.—C. fusiformis.—*Duj.*
D'une infusion de mousse, grossi 500 fois."†

* 'Histoire des Zoophytes infusoires.' Paris, 1841.

† Let me draw the attention of my readers to the fact that, according to the theory of "spontaneous generation," this form must have been *produced* by the three totally different substances in which they were found by Balbiani and Dujardin.

In September of the same year, I found this same form in some distilled water into which I had washed a little of the dust from my study window, and was induced in consequence to examine successively dust taken from the high road near my house, which I sprinkled upon distilled water, and *pure boiled distilled water only*, exposed in a clean white saucer to the atmosphere. At the furthest, within a week, I found (along with others) this little type, its presence in the saucer of pure distilled water being accompanied by a slight deposit of dust.

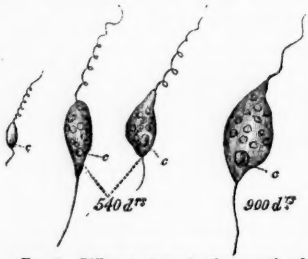
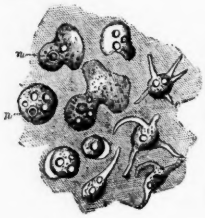


FIG. 3.—Different stages in the growth of *Cercomonas fusiformis*, or *acuminata*, found by the author in pure distilled water. (C. contractile vesicles.)

I followed it in its development from the minutest monad, and was satisfied at length, from the rhythmical movements of its "contractile vesicle," that it was entitled to be called a living infusorium. Since that time I have repeatedly met with it both in pure distilled water and in infusions; and as recently as last June, I found it in sufficient numbers in pure distilled water to enable me to include it in the illustration from nature which accompanies this paper (p. 613).



Another form, *Amœba Gleichenii*, belonging (as the protozoa are now classed) to a still lower group, was observed by Dr. Balbiani in the same infusions with the above-named type, and the accompanying is also engraved from his original drawing of it.

FIG. 4.—"*Amœba* (*Gleichenii?*)"—(n. nucleus.) From Dr. Balbiani's infusions.

I presume that my coadjutor gave it this designation, because the form having the nearest resemblance to it is thus figured by Dujardin.

FIG. 5.—Dujardin's Amœba Gleichenii.

If it were fair to criticize the scientific appellations bestowed upon these minute particles of organized protoplasm, I should say Dr. Balbiani would have done better to give a new specific title to *this* Amœba, for it is widely dissimilar from Dujardin's; but, be this as it may, I have frequently met with similar types in infusions, and last June* *the same* (which I venture to call Balbiani's) appeared in such

* It is right to state that the cause of my success during that month was the high temperature, accompanied by a favourable wind for the conveyance of dust into my vessels of distilled water.

numbers in pure distilled water, that I had ample opportunities to verify and sketch it under the microscope.

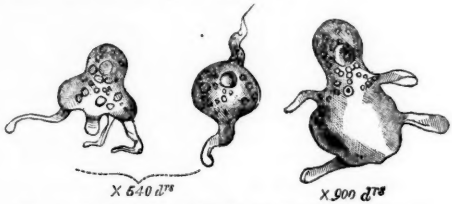


FIG. 6.—*Amœba Balbianii*, found by me in pure distilled water.

My figures are more highly magnified than Dr. Balbiani's; but an inspection of the Plate, and a comparison with my colleague's figures, will exhibit the identity.

Lastly, Dr. Balbiani found in his infusions, both animal and vegetable, a little ciliated type, *Cyclidium glaucoma*, and wrote to me some time afterwards that he had found the same form in moistened dust wiped from his window. He sent me a drawing, which it is, however, unnecessary to append. Here, then, we have characteristic types representing three distinct groups of *Protozoa* which have been observed at the same time in infusions of various kinds, and then the identical types subsequently traced to the atmosphere itself, or to the dust which it holds in suspension.

But the objection, refined as it may be, might not improbably be raised by the advocates of heterogenesis against these experiments, that perhaps the infusoria which I have thus traced in pure distilled water are spontaneously produced from the particles of organic substances which find their way along with dust into the vessel containing the water.

It is, therefore, advisable to meet this difficulty beforehand, and I can best do so by repeating here an account of one of my experiments, described last year before the members of the British Association.* I had exposed (July, 1863,) some pure distilled water in a glass vessel, placed in a box covered with a glass lid, which was left partially open, and after a few days could trace scarcely any appearance of life in the water, inasmuch as the glass cover had intercepted the dust to such a degree as to have become to some extent opaque through the deposit. I therefore removed the dust from the glass lid into the contained vessel, by washing it with a little distilled water, and then left it fully exposed to the atmosphere.

The very next day I re-examined the vessel of distilled water. When exposed on the previous day, the dust had clouded it a little, but now it had settled at the bottom as a fine film or deposit. On pouring off the water carefully, and examining this deposit as it lay in the vessel with a low power (about 75 diameters), it appeared to consist of a number of minute siliceous fragments, interspersed with

* Sub-Section D. "Life in the Atmosphere."

organic particles, both of which seemed to float in a gelatinous film somewhat resembling balsam. Several small cysts, coloured green, were also visible. On adjusting a higher power (200 diameters*), and covering a portion of the thin glass, this gelatinous film proved to consist entirely of transparent colourless "monads," possessing no locomotion, but exhibiting a slight tremulous movement.

I carefully poured back the water into the vessel, and left it until the day following, when, on examining the water, I found it to swarm with "monads." Even those under the covering glass, which I had left undisturbed the day previous, were locomotive and very active. In their forms and movements they resembled various kinds of infusoria, some moving forward with a rapid rotatory motion; others swinging to and fro, progressing more slowly; and others again reminding the observer, by their movements, of the loricated infusoria. Some were globular; others, ovate; and others again, flattened discs. Many were undergoing longitudinal subdivision, and the largest were about 1-700th of an inch in diameter. Transparent vegetable fibres were also present, and these were covered with sessile "monads;" some cysts appeared to have discharged their contents, and were floating empty in the water. At this period, my investigations and experiments, which had been long protracted, were brought to a close.

Was it possible, I would ask, that these swarms of living organisms (to whatever groups they may have appertained) could have been spontaneously produced in a single day from the particles of organic matter which, along with the mineral molecules, were imbedded, as it were, in their aggregated mass? Or is it not more likely that the deposit of dust contained, besides vegetable and mineral particles, a vast number of zoospores, requiring but warmth and moisture to call them into active life? Which is the most rational and scientific method of accounting for their appearance, whether our judgment be based upon theory or experiment?

Let me now add a few of the general results of my prolonged investigations to the special cases already named.

In the course of my experiments with distilled water, I have carefully and repeatedly examined,—1st, dust taken from window-panes, and from other common-place localities at home; in this I have found the following forms, of which I have retained more or less accurate sketches made at the time of observation:—

"*Cercomonas fusiformis;*" various *Amœbæ* (some of them undescribed, as far as I can ascertain), one or two *Vorticellæ*, *Enchelis*, *Kerona* (?), cysts, from which swarms of minute zoospores issued on their being broken by pressure, and in one case I found, in pure water containing nothing but the usual slight deposit occasioned by exposure to the air, what appeared to be the larval form of one of the *Entomostraca*, of which I have no doubt an ovum had found its way into my distilled water.

* I give the measurements in diameters in all cases, chiefly because my instrument is by Schieck, of Berlin, and the English measurements by $\frac{1}{4}$ths, $\frac{1}{8}$ths, &c., are unknown to the foreign makers.

I have also seen plant-cells in great number and variety, and on one occasion the contents of my vessel were, after a few days, tinged green with *Protococcus pluvialis*, as much as if they had been taken from a rain-water cistern.

"*Vibrio*," "*Monas*," and the other types of the partisans of heterogenesis, were of daily occurrence.

In all these cases, I have not the slightest doubt that the atmosphere was the medium through which the germs or spores were conveyed into the distilled water, and it was often a matter of surprise to me that such a number and variety of forms should have become even partially developed, where so little nourishment was afforded for their increase. Let me also add that, contrary to what has been stated by the advocates of heterogenesis, I have always found that the more freely the water was exposed to the air, and the warmer the temperature, the more abundant and diversified were the living types, and the more rapid was their development.*

2nd. I have examined dust shaken from samples of various kinds of cotton rags which had been imported from the following localities:† Egypt, Japan, Tunis, Trieste, Melbourne, and Peru, and in all these different kinds I have found well-marked types of protozoa.‡ To a great degree these types differed from those which I had observed in dust at home, being more active, and highly organized.

In one case I succeeded to some extent in tracing the growth of several of those obscure little forms known as "vibrio" to the annulated, ciliated type here delineated, and saw them cast off ring after ring, which then assumed an independent existence, and commenced to subdivide and extend in length.

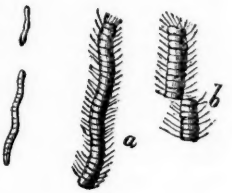


FIG. 7.—Various stages of a Vibrion found in the dust from blue Egyptian rags. *a*. An animalcule 1-150th of an inch in length. *b*. The animalcule casting off several ciliated rings.

As, however, it may be objected, with some show of reason, that the living types from such sources as these afford no *direct* proof of their presence in the atmosphere (although it is well known that the dusty rags imported into this country are for the most part picked up in the streets abroad), I am content to let this evidence go for what it is worth in the eyes of my readers, and mention the matter chiefly as a hint to microscopists where to seek new types of protozoa; but if there be any who are disposed to doubt the presence in the atmosphere of the germs or zoospores of many of those common infusorial types which are supposed by the partisans of "spontaneous generation" to be abnormally produced from the infusions in which they are often met

* I have been the most successful with a shallow white saucer.

† The dust was in all cases carefully sifted through muslin on to the surface of distilled water, and fell to the bottom of the vessel as a fine deposit.

‡ As described in short memoirs read before the Academy of Sciences, Paris, 1863; and Sub-Section D, British Association, 1863.

with, I would recommend them to verify or controvert my statements by the following simple experiment:—

Let them procure some distilled water from a source which is certain to be pure; and to make assurance doubly sure, let it be boiled, or (as Dr. Rolleston, of Oxford, has suggested*) passed slowly through a red-hot platinum tube.

This water should be exposed in an open situation, in a good-sized saucer or soup-plate, and fresh distilled water added day by day, to supply the place of that which evaporates.

The exposure should take place in warm weather, if possible with a light breeze, and not too soon after the air has been purified of its floating contents by a shower of rain.

In a few days, if ordinary success attend the experiment, an inconsiderable sediment of dust will have settled at the bottom of the saucer, and drops of the water, along with a little of this sediment, should be submitted to *careful* microscopic investigation. If I am not greatly mistaken, judging from my own experiments, the most conspicuous types will be found to be those little fragments (more or less definitely shaped) of organized protoplasm known as amœbæ, and the observer will probably notice many interesting phenomena in connection with their growth, permanent changes in form, mode of subdivision, &c., to which my limited space has allowed no reference. When the field is carefully viewed with a high power, there will also probably be found in considerable numbers the little fusiform monads (so frequently referred to in this paper), for in most of my investigations these have first appeared.

With favourable weather and perseverance, other and probably higher forms will in time become apparent; and I trust that if no other good result from the publication of these imperfect observations, they may lead more careful investigators to favour the microscopical world with valuable contributions to "atmospheric micrography"—contributions of a different kind to the negative ones formerly published under that title by Dr. Pouchet, the zealous champion of heterogenesis.

For the benefit of those, however, whose time or occupations prevent them from investigating for themselves, and who are willing to accredit me with accuracy of observation, I have appended a plate, which will give some idea of the appearance of the microscopical contents of distilled water, after a few days' exposure to the atmosphere in fine weather; but I must state, to avoid misapprehension, that although all the forms and others besides may be contained in the same drop of water, they will probably not appear at one and the same time in the field of the microscope.

The objects represented in Fig. 1 (commencing at the top) are, a fragment of organic matter upon which a swarm of minute zoospores and one or two young ciliated infusoria appear to be regaling themselves; then, between the bright crimson hair (animal or vegetable) and a green plant fibre, probably one of the confervoid

* Sub-Section D, British Association, 1863.

I

II

I CONTENTS OF A DROP OF PURE DISTILLED WATER AFTER 14 DAYS EXPOSURE TO THE ATMOSPHERE (MAGNᵖ 270 DIAMETERS)

II LIVING ORGANISMS, &c, FROM A SIMILAR SOURCE, 900 DIAMETERS

M & N Hanhart imp

algæ, are seen four amœbæ, and two of the fusiform ciliated "monads" (*Cercomonas fusiformis*); a group of free floating cells, some of which are subdividing, may be observed below; zoospores, or the young of ciliated infusoria, and "vibriones," make up the living contents, whilst a couple of fragments of hard, transparent mineral, probably silex, held together by some softer mineral substance, complete the little group of objects, all of which are magnified 270 diameters.

In Fig. 2 we have one of the larger plant-cells, a little sharp fragment of silex, amœbæ of various types (one very active kind undergoing subdivision), the fusiform "monad," and two young ciliated infusoria, all represented as they appear under a lens magnifying 900 diameters.

But it may be said by the partisans of "spontaneous generation," that the presence of germs in the atmosphere is no absolute disproof of their theory, and they may still maintain that it is possible for inorganic elements or organic compounds so to combine "spontaneously," as to form infinitely minute germs or cells, which are invisible under the highest powers of the microscope.

For the possibility of such a combination, by *artificial* means, they might appeal to the opinion expressed by at least one high biological authority, Professor Huxley, who says (as it was already stated in the Introduction to this Journal), that he believes it possible, before half a century has elapsed, that man may be able to take inorganic substances, such as carbonic acid, ammonia, water, and salines, "and be able to build them up into protein matter," and that that protein matter should "begin to live in an organic form;"* and, for the reasons assigned at the commencement of this paper, it appears to me also that they have the indirect countenance of all thorough believers in progressive development through secondary causes.

Nor would I for a moment venture to deny the *possibility* of such a phenomenon; for, however contrary it may be to analogy and experience, it is impossible to say whether or not the same natural laws operate in the creation of these still invisible forms as in that of the visible organized types.

As Dr. Child has said, some of these forms are no more entitled to be considered independent organisms than white blood-corpuscles, &c.; and I think he might with safety have added, after the publication of Dr. Beale's researches on blood-corpuscles, that some of them are much *less* deserving of the rank of living organisms. It would be presumptuous, then, to deny that such lowly forms may not be created to-day, either artificially or spontaneously.

But that is not the ground hitherto taken by the advocates of "spontaneous generation." They deny the existence of the germs of infusoria in the atmosphere, and would have the scientific world accept their theory as sufficient to account for the presence of all the

* 'Lectures to Working Men.' Professor Huxley is, however, a disbeliever in heterogenesis, and considers that through Pasteur's experiments the doctrine has "received a final *coup de grâce*."

known forms of protozoa (if they do not go still further) which are found in infusions. And upon what biological evidence do they claim a scientific status for their doctrine?

Mainly on the ground, as already observed, that when they have sought to exclude the air from infusions (no doubt as conscientiously as possible), there have, after a certain time, appeared in them "monads," "bacteriums," and "vibriones;" these objects being, generally speaking, and notwithstanding their high-sounding appellation, minute moving *specks*, or lines, even under highest microscopical powers, and concerning which the least scientific reader knows just as much as the most learned investigator.

In this, the popular sense of the term "spontaneous generation," I am certainly no believer; and I have little doubt that the time is not far distant when all those lowly types, now known as protozoa, will be traced in their earliest stages to the atmosphere, the dust of the road, of our parlour windows, and indeed in every place into which dust and air penetrate.

It is the common-sense explanation of their presence; for what is more natural than that, along with the dust, which is dried mud, the wind should also waft about the light zoospores of those minute forms of which the stagnant pool is the habitat? And it is the solution strictly in accordance with scientific experience, for, without reference to the great homogenetic law traceable through the whole organic realm, we have the indubitable fact, that the more lowly the organisms, the more widely are their reproductive principles diffused in the elements.

ON THE FORMATION OF CORAL (*Corallium rubrum*).

By Professor H. Lacaze Duthiers (École Normale supérieure, Paris).

Coral has been in request from the earliest times for the purpose of personal adornment, while its form and properties, which denote at one and the same time the plant and the stone, so masking its real origin, have excited the curiosity alike of the fashionable wearer and of the devotee of science. Its true nature has, however, only been recognized within the last hundred or hundred and fifty years. This has been, in a great measure, due to the absolute impossibility of arriving at any accurate conclusion on the subject without close observation of the animal while living, and to the great difficulty of meeting with it in this condition. As soon as it is removed from the water it dies, and even though preserved in fresh and constantly renewed water, with the most scrupulous care, it still too often speedily perishes. To obtain, therefore, the opportunity for close examination, one course only is open to the inquirer; he must be present at the capture of the animal, and proceed at once with his

investigations; and let it be observed that this mode is not always either easy or even possible, for most commonly the *popieri*, or boat masters, are but little disposed to receive on board strangers, whose only object they deem to be that of mastering their secrets and profiting by their skill in finding the localities most favourable for obtaining an abundant supply of coral. They cannot understand that anyone would expose himself to the discomforts of their mode of life, merely to satisfy a curiosity which they are not able to comprehend, by poring over a branch of living coral as it is withdrawn from the water.

I had obtained, at Bonifacio, in Corsica, a promise of all that would be necessary for my purpose; the most gracious assent was given to my expressed desires, but when night came the expedition put to sea, and I saw no more of those upon whose aid I had too confidently reckoned. The search for coral, moreover, is not managed on the same plan as other fisheries. The coral-seekers have to look for banks in very different, and often far distant, localities, according as the wind happens to be favourable or otherwise. They therefore carry provisions for some considerable time, and the period of their return to the port from whence they sailed is indefinite to a degree. I encountered one day, in the Gulf of Propriano, on the shores of Corsica, a little fleet of sixty coral boats; a week afterwards not one remained, nor did I again fall in with them. During my stay at Calle all the fishermen sailed in the month of June for the island of Galito and the waters of Bizerta; they did not return until the commencement of August.

It will be no subject of surprise, then, if the naturalist hesitates before he undertakes a voyage which is so uncertain in the time it will occupy, and constantly attended with fatigue and discomfort. These difficulties, to which indeed many others might be added, serve to explain the slow advance of knowledge in this branch of inquiry, for the task of obtaining living coral, now sufficiently arduous, must have been still more so in former years. It should be observed, however, that if the materials can only be obtained with comparative ease by the dredge, the necessary inquiries may be made with far greater facility.

Leaving unnoticed the fables and prejudices of the ancients, and without entering upon an unsuitable historical *résumé*, we may remark that Reaumur and Swammerdam classed coral among stones; that Marsigli, having seen its flowers, regarded it as a plant; while ultimately the discovery of Peyssonnel assigned to it, in 1729, its legitimate position in the animal kingdom. Reaumur, a singularly truthful and clear-sighted observer, thoroughly recognized the great importance of direct observations, and succeeded in obtaining orders from the Duke of Orleans that messengers should start on foot from Marseilles, to bring to him with all possible care the coral freshly taken on the coasts of Provence. Unfortunately the precious burden had far too feeble a hold of life, and the distance over which it had to pass was much too great. The coral arrived in Paris, it is true, but quite dead, and its examination elicited no new facts; its only result, indeed, being to confirm Reaumur in his erroneous impressions. It is worthy of special note that the most important

discoveries have been made by those observers who, regardless of trouble, fatigue, and dangers, have trusted themselves at sea, and have lived the mode of life of the coral fisher.

No one would, indeed, dream of assigning a higher scientific value to the researches of Marsigli and Peyssonnel than to those of Swammerdam and Reaumur; but on which side do we find truth and accuracy? The first-named naturalists elicited new facts, and saw things of which the latter remained ignorant, from this one cause—that they studied the animal still living, and in its normal conditions, and did not draw their conclusions from the dried-up specimens of natural-history cabinets. Have we not here a striking proof of the advantages to be derived from studying animal forms, not alone among the accumulations of museums, but also under those conditions of existence which are peculiar to them, meeting with them, as it were, in their own homes? In this line of inquiry lies, indeed, the future advancement of the natural sciences.

The discovery of Peyssonnel seemed so incredible to Reaumur, that he would not even publish the name of its author. De Jussieu was not more open to conviction, and it was not until after the publication of Tremblay's memorable investigations in regard to the fresh-water hydra, that attention was directed to the dicta advanced by Peyssonnel. Then Reaumur wished to explain away his opposition, but it would seem that the ardent naturalist and traveller, confident of the accuracy of his researches, and mortified by the opposition of the French *savans*, had forwarded his memoirs to England, where they were examined and published, from 1756 to 1759, in the 'Philosophical Transactions.'

Peyssonnel had merited a widely different reception. An impetuous and courageous enthusiast, a true child of the South, he did not shrink before danger or fatigue during his stay on the coast of Africa, then so hostile to an explorer. On other grounds, too, he had well earned the esteem of his fellow-citizens. In 1720, during the terrible plague which desolated Marseilles, he shut himself up with his father in the hospital of the Holy Ghost, there to attend to the plague-stricken, abandoned by all others.

His admiration for nature induced him to devote a part of his fortune to the founding of a prize to recompense studies in marine natural history. The Academy of Marseilles refused it.

It is painful to see Peyssonnel, full of success in his first endeavours, withdraw himself from the scientific arena when the *savans* rejected his discovery, which undoubtedly was one of the greatest of modern times. He no doubt resented the erroneous judgment upon his labours with the promptitude and warmth of feeling manifested by every man who, being a follower of truth and loving science for herself, feels that he is crushed by the lofty position of those who judge him rather than by the force of the arguments which they have marshalled against him.

He accepted the post of Royal Physician at Guadaloupe, and it would appear that in so doing he exiled himself at the same time from his country and from science. No further communication is

extant from him to the Academy. It is probable, however, that after he had withdrawn himself from French scientific circles, he still continued to direct his attention to another country, since he addressed his work to the Royal Society of London; then resigning himself to that loss of heart which injustice invariably induces, he ceased to labour, and never again returned to France. The date of his death even is not accurately known.

Peyssonnel was unfortunate. His devotion to the welfare of his fellow-citizens during the fearful epidemic at Marseilles; his generous and liberal offer for the endowment of a prize; his great discoveries in the highest of the natural sciences, transferring to the animal realms a multitude of hitherto so-called plants; these should have secured for him in his own country such a position as would have kept him faithful to science. France would not then have been compelled to regret her indifference to an extended and prolific subject in science, nor to mourn over her neglect of a man who had done her honour; permitting even the date of a valuable discovery, which belonged to her, to be inscribed in the archives of Great Britain.

There being no doubt regarding the animal nature of coral, we have now to inquire into its reproduction and development.

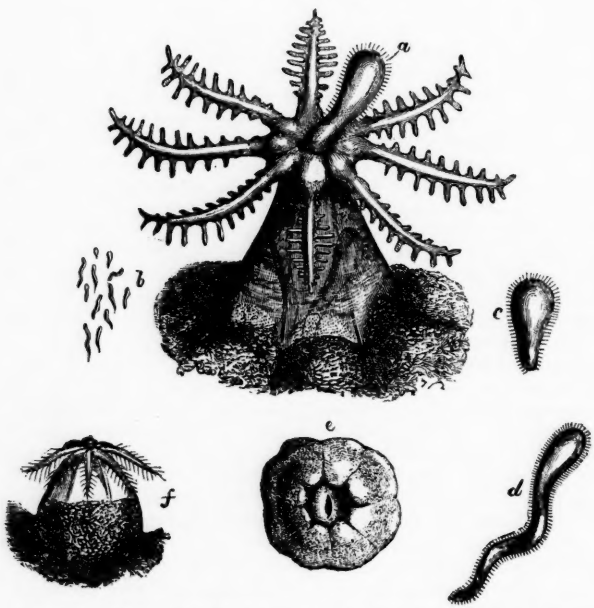
If the attempt to keep coral alive should prove successful, and observations be instituted in the fine season, that is, from May to September, at the time when reproduction is proceeding, we shall find that little white ovoid bodies (Fig. 1, *c*) escape from the centre of the graceful rosettes with which the surface of the animal is covered; these in the first instance sink to the bottom of the water, but a short time afterwards acquire an elongated form, and are endowed with the power of movement. These little bodies are not, strictly speaking, ova, since they are already provided with organs of locomotion. They must be considered as embryos, or young polypes.

They possess considerable activity, swim freely, avoid one another in their onward course, and ascend or descend in the glasses in which they are kept. Shortly after their first appearance, or when the water in which they are placed is renewed, their activity is much increased, and they grow considerably in length. They are then completely vermiform (Fig. 1, *b*, *d*).

These leading facts have not been observed without much labour. During the three months of June, July, and August, in spite of every care, and notwithstanding my choice of a very convenient locality, near to Calle, for the carrying out my experiments, the coral submitted to examination died in a most provoking manner. It was in vain that I searched for it myself, and with my own hands collected it with the greatest care from the nets; some hours after my return to the shore it was covered with a thick coating of mould. Judging by analogy with what I had seen among the Gorgonidæ and the true polypes, I took the precaution, towards the middle of August, of going on board one of the coral boats for several days, and then and there to open all the living coral which might be brought up. I hoped to succeed in procuring a premature development of the young polypes, and so to prevent their death; a mode of experiment which had answered my expectations

in the case of the Gorgonidæ, Alcyonidæ, and Asterids. I soon collected an enormous quantity of ova, but not one of them survived. I began to despair, attributing these protracted failures to the heat, when at length, in the month of September, after the temperature had somewhat fallen, I obtained an abundance of lively young ones, and was able at once to follow their development.

Fig. 1.



a. Formation of the vermiform larvæ of coral. *b*. Larvæ, or embryos of natural size. *c*, *d*. The same, magnified. *e*. Disc resulting from the metamorphosis of the worms. *f*. Young polype, with tentacles already provided with processes.

The ova of coral, as we shall soon see, are at first spherical and naked; as they become developed, they increase in length, and are furnished with a well-marked central cavity, communicating with the surrounding fluid by an opening which later on becomes the oral aperture.

When they emerge from the cavity in which they have commenced their transformation, they have acquired a covering of vibratile cilia (Fig. 1, *c*, *d*), and they then completely resemble white worms. They swim with the mouth directed backward, while their larger extremity, or base, looks forward. They have also a tendency to aggregate in clusters, and subsequently incline to adhere to the walls of the glasses,

or to objects with which they may come into contact; this tendency is favoured, too, by their mode of progression. Thus, even their activity is a principal cause of their losing the freedom of movement, from its favouring the close adhesion of the posterior part of the body—that part which will ere long be the analogue of the base of the Actiniæ and other adult Zoanthidæ. This proneness to apply themselves to other objects appears specially manifested when the elongated or vermicular form is about to disappear; then the embryos sink down upon themselves, and losing in height what they gain in breadth, change their form into that of small lens-shaped discs (Fig. 1, *e*), in the middle of which the more slender extremity, bearing the mouth, buries itself, and becomes surrounded by a circlet of little cushions. Upon these cushions, and consequently around the mouth, eight small nipple-shaped projections very soon show themselves; these are covered by delicate processes, which subsequently become by elongation the arms of the polype (Fig. 1, *f*). Whilst carefully examining with a lens the stones brought from the bottom of the sea by the nets of the coral fishers, I found little red objects, a quarter and even a half of a millimètre in diameter, which a microscopic investigation showed to be the young bases of coral. Smaller than those which had been formed and fixed in my aquaria, they only as yet enclosed one single animalcule. By further search I was able to follow out all the stages intermediate between the most simple individuals and the most complex branches. Afterwards retracing my steps, I could pursue my inquiries up to the point of the most complete development.

Soon after the young polype has fixed itself, and when its tentacles have become well developed, its white colour disappears, giving place to the characteristic red of coral. (Fig. 1, *f*, represents a young polype of half a millimètre in diameter.) It is difficult to depict the delicacy and elegance of the animal at this stage of its growth. The base or body is of a beautiful rose-colour, while a white coronet formed by the arrangement of the tentacles occupies the upper part. It sometimes presents the illusion of a charming white flower, with its graceful petals surmounting an urn.

When the first animal, the development of which we have just traced, is complete, a new phase of growth is entered upon. There appear, one by one upon its sides, small nipple-shaped projections, true buds or gemmæ (Fig. 2, *b*, *d*), having their origin in the very tissues of the animal, and provided with a single orifice covered with tentacles; these at length become transformed into so many new polypes, fac-similes of the original animal.

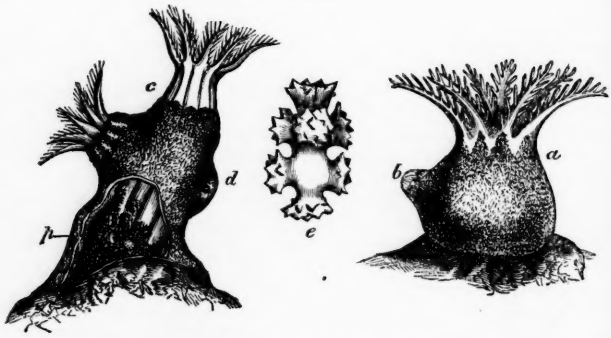
These outgrowths do not separate themselves from the original stock; and since they in their turn become centres from which budding takes place, we may well understand how rapidly the whole number will increase.

This peculiar faculty of increasing by budding is shared by the corallines with vegetables; and to it must be referred the formation of branches and twigs, and the increase in length of the parent stems. But a distinction must be drawn between the multiplication of the number of bases or branches of coral and the increase in number of

the polypes. The one is due to the development of ova, the other is accomplished by the repeated appearance of buds.

Before proceeding further, it will be necessary to give some general idea of the plan of organization. Two very different parts may be

FIG. 2.



A young polype, *a*, commencing to throw out buds, *b*; a colony, *c*, which has two polypes and a bud, *d*. At *p* the tissues are laid open, so as to exhibit the first traces of the polypidom in process of formation. *e* is one of the spicules, magnified 900 times, which exist in the crust of coral, and which by agglomeration produce the polypidom.

recognized in living coral by the most superficial observation. The one—situated externally and, when recent, perfectly soft; when dried up, friable and easily powdered—constitutes the polyp-bearing or animal layer (Fig. 3, *a*). The incorrect though convenient term which is frequently applied to this part of the animal is "bark." The other, centrally placed, solid and resistant, forms the axis, polyp-stem, or trunk (Fig. 3, *p*). This part only is available for purposes of ornament.

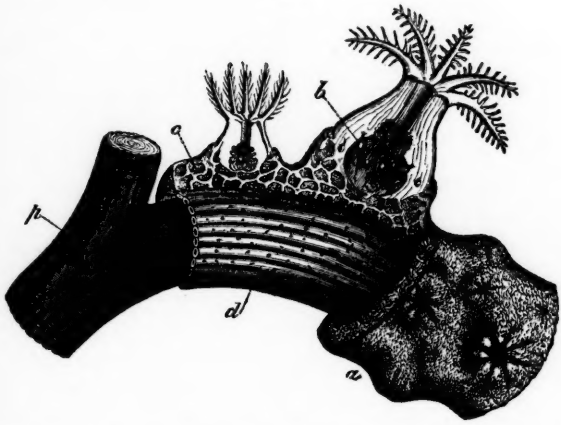
The surface of the cortical portion, when it is well preserved, and especially when quite recent, appears to be covered with minute bosses or little elevations. These bosses are pierced at their apex by a fine perforation with radiating folds, and are hollowed in their interior to form a cavity, from whence the polypes, or "nettles," as Peyssonnel called them, appear to emerge.

Nothing can compare with the graceful arrangement of these little animated flowers; the eight fringed arms with which they are provided are in continual movement; extend themselves in every direction, and then again coil themselves up to convey to the central mouth the prey they have seized. They are milk-white in colour, and stand out in admirable contrast with the lively red of the base. Michelet, therefore, is in error when, in his book on the Sea, he calls them flowers of blood-red tinge.

The tissue of the cortical portion is cellular, soft, and delicate. It is furrowed throughout by vessels, either irregular in pattern (Fig. 3, *c*), or lying side by side and parallel (Fig. 3, *d*), and which put

the polypes in direct communication with one another. It encloses also innumerable little calcareous corpuscles (Fig. 2, *e*), red in colour and microscopic in size; these characteristic objects enabling the observer to recognize coral even in its earliest stages. As to the polypes,

FIG. 3.



Part of a branch of coral, magnified and prepared so as to show the polyp-stem, *p*, channelled throughout; to each channel a vessel, *d*, corresponds; *a*, "Bark," permeated by small vessels, *c*, putting the polypes in communication with one another; and a polype, *b*, drawn with ova suspended in the folds of the general cavity.

the walls of their bodies are represented by the bark itself, and their organs exist in the form of slender lamellæ (Fig. 3, *b*), the edges of which, somewhat cushion-shaped and contorted, have a slight resemblance to the convolutions of the intestinal canal.

We have now once more to revert to the question of development, and to inquire how the axis or polyp-stem is formed; the only part, as before said, which is available for personal decoration. The calcareous corpuscles of the cortex are formed soon after the young coral has become fixed or sessile, and on their presence depends the characteristic red colour. In the first instance they are equally disseminated throughout the tissues, but subsequently they multiply and accumulate as nuclei; then a red cement is deposited around them; and these distinct centres, later on, not only unite with one another, but become closely cemented to the submarine bodies upon which the young polype has become fixed. This is the origin of the axis or polyp-stem. It is the same with young polypes as with adult branches; the latter maintaining at their terminal points a perpetual juvenescence, owing to their continued growth. And we find under their cortical covering a partially-formed axis bristling throughout with microscopic asperities representing the corpuscles; these are still recognizable, imperfectly

fixed in the cement. At the base of the adult branches the cement is constantly deposited in much greater quantity than towards the extremities, and to this fact the increase in bulk is in great part due. It would appear, too, that the imbedded corpuscles are less numerous at the lower part than at the apex, or in the more recently-formed tissues.

In the interests of general zoology, or the philosophy of the science, the determination of the origin of the axis is of material value, and to this point especial attention should be directed. In some families of the coralline group the polyp-stem is flexible, transparent, and recalls in some measure the horny or epidermic structures among the higher animals. Such are the Gorgonidæ, whose zoological affinities bring them into close relation with coral; and hence, indeed, some authors have been led to believe that the axis of the latter, in spite of its solidity, was constructed by the induration of the epidermis just as we find the polyp-stem to be formed in the Gorgonidæ. It is, however, difficult, after the preceding investigations, to adopt this explanation, since in the interior of the coral axis we find elements similar to those which are disseminated through the deeper parts of the body of the polypes. In this matter a direct application of embryogenic researches has been made available for the purposes of classification.

In conclusion, a few words may be devoted to the phenomena which precede the birth of the embryos, and which have not as yet received notice. Fertilization is accomplished under varying conditions, these having reference to the arrangement of the generative glands, and to the distribution of the individuals of different sexes upon the branches. The polypes, sometimes male, at others female, and lastly, again, hermaphrodite, may be found in close proximity with each other on a single branch, or separate and attached to different branches, where they are clustered together (and this is the most frequent condition), the number of one of the sexes is in excess of the other, very rarely a branch is unisexual, and I have never met with one exclusively composed of hermaphrodite forms. These latter, indeed, are relatively less numerous, and are most commonly scattered irregularly among others, or completely isolated in their very midst. The distribution of the sexes is not, therefore, subject to any special rule. Fertilization, it would seem, then, is sometimes direct, and carried on in a single polype; at other times indirect, and effected between two individuals on the same, or on distinct branches, always, however, taking place in the general cavity of the body, since it is in this place that the ovum remains and is developed. Further, too, it would seem that the fecundating fluid must be carried to the female polypes by currents of water, as is the case with the mollusks which are of separate sexes, and furnished with adherent shells. The generative glands have no special well-marked form, as in most other animals; their products originating, so to speak, separately, at the base of the intestine-like folds of the general cavity, are contained in capsules which become prominent in proportion to their development, and which are ultimately attached to long pedicles. The ova, after the rupture of the pedicle by which they are suspended, fall into the general cavity and

remain there, undergoing transformation up to the moment of the birth of the embryo. The spermatozoa becoming free by the rupture of the capsule which enclosed them are ejected, and fertilize the ova of the females, either directly, if these be near at hand, or by comparative accident if they are not in immediate proximity to the male polype. The emission of the spermatic fluid of the male can be easily detected by direct observation, for it is only necessary to examine some of the living coral at the moment of reproduction, to see the polypes throw out jets of a white liquid, which forms a cloud in the water, and in which, also, the characteristic male elements or the spermatozoa will be discernible.

The ovum, as we have just seen, after detaching itself from the intestiniform folds, falls into the general cavity, where it is fertilized and undergoes its first changes; but in this same cavity another important junction is also accomplished, namely, that of digestion. The same organ therefore serves both as a *stomach* and a *matrix*, or more properly speaking as an ovisac, and in it two substances, under conditions which appear to be similar, can nevertheless undergo modifications thoroughly opposed to each other; for the one is dissolved and liquified, while the other increases in bulk, and produces a new being. This physiological peculiarity cannot fail, from its strangeness, to attract attention; it shows what an immense difference exists between the higher and lower animals, and how difficult it is to judge *à priori* of the one by the other.

As a summary, it may be said that coral follows the ordinary laws of reproduction, and does not present the variations which are met with among some of the inferior animals. For a very short period after its birth it enjoys the power of movement, but as soon as it begins to undergo its metamorphoses the ability to move is lost, and the animal fixes itself in one place, which it does not afterwards desert. Then, too, its early form is lost, and it is no longer possible to recognize in its branches, so elegant in form and so rich in colour, the little white worm from which these were developed. All these facts have, without doubt, a special importance in the history of coral; but they show, also, how the study of the inferior organisms reveals each day some new and unexpected facts; how little the phenomena of life throughout the animal series are as yet understood; and they teach us that such investigations should be conducted with extreme care, and that due reserve and caution should be exercised in reasoning from analogy, and in the application of what we regard as universal laws.

ON THE CONSTRUCTION AND MECHANICAL PROPERTIES OF SUBMARINE TELEGRAPH CABLES.

By William Fairbairn, C.E., LL.D., F.R.S.

Twenty-four years have now elapsed since Professor Wheatstone suggested to the Select Committee of the House of Commons on Railways, the construction of a submarine telegraph between Dover and Calais. Since that time 11,000 miles of cable have been laid, only a little more than one-fourth of which can be said to be in a working conditon; amongst the unsuccessful attempts being the Atlantic cable, measuring 2,200 miles; the Red Sea and India Telegraph, of 3,499 miles, and sundry shorter ones, measuring collectively about 2,300 miles. To account for these misfortunes is a work of some difficulty, owing to the many causes which may affect the integrity of the insulation, or the continuity of the conducting wires. The 8,000 miles of failure have not been, however, wholly lost. They have been the means of accumulating a vast amount of experience, and have suggested remedies for the inevitable difficulties which have to be encountered, now as before, both in the manufacture and in the paying-out of deep-sea cables.

There are two descriptions of cables required for marine construction: one for shallow water, where, owing to the liability of injury from ships' anchors, or the abrasion against rocks or gravel, it is necessary for the insulated wire to be surrounded with an extra strong covering of wire and hemp saturated with pitch; and the other for deep-sea purposes, in which case, as the cable when once laid is supposed to lie perfectly quiescent at the bottom of the ocean, no more strength nor protection is needed than will shield the wire and its insulating coating from injury during the paying-out. Respecting the shallow-water cables, in which category we class the line between Dover and Cape Grinez, laid in 1851; the line from Dover to Ostend, laid in 1853; the one from England and Hanover, 280 miles long, laid in 1858; one between Folkestone and Boulogne, laid in 1859; and one between England and Denmark, 350 miles long, also laid in 1859, all the above are the property of the Submarine Telegraph Company. In addition to these, there are several others which may come into the same class, such as the lines between England and Holland, and the Channel Islands cable, laid between this country and Alderney, Guernsey, and Jersey, in August, 1858.

Amongst the most important of the *deep-sea* cables is that of the Atlantic Telegraph Company. This company obtained an act of incorporation in 1854, which conferred, amongst other privileges, the exclusive right of landing cables on the coast of Newfoundland, or the adjacent islands, for a term of fifty years. The company also obtained a grant of 14,000*l.* per annum from the British Government, and a similar one from the American Government, so long as the line was in working order.

Upon these guarantees and privileges the company was formed, and

the cable was manufactured, one half by Messrs. Glass and Elliott, of Greenwich, and the other half by Messrs. Newall and Co., of Newcastle-on-Tyne. As one article has already been devoted to the history of this ill-fated cable,* we will not further allude to it, than to say that the failure of this enterprise may be attributed to the want of care and proper supervision in the manufacture, and, to use the words of the commission, "practical men ought to have known that the cable was defective, and to have been aware of the locality of the defects before it was laid." We might multiply instances of several other similar failures, such as the Red Sea and India, the Spezzia and Corsica, and the Bona and Cagliari cables, all of which are now useless.

In deep-sea lines there are three points which require careful consideration, and which appear essential to success, namely—the tensile strength and conducting power of the cable, perfect insulation, and machinery calculated to pass the cable with safety from the ship into the sea. If this latter can be properly effected, we may venture to assert that a well-insulated cable, when once laid, may be retained for a series of years in satisfactory working order.

In the forthcoming Atlantic telegraph, every possible precaution has been taken to have a sound and suitable cable in the first instance, and Messrs. Glass and Elliott have not only conformed to the recommendations of the scientific committee, but they have chartered the Great Eastern steamship for the exclusive purpose of laying the cable, commencing probably at Newfoundland, and continuing the process of paying-out, as we hope, without break or interruption, till it is safely landed at Valentia. As the construction of the cable is equally important with the skill with which it is laid at the bottom of the Atlantic, it may be interesting to compare the present cable with those previously laid down, and to show with what precaution the directors of the company have undertaken this important and precarious task.

In all the cables we have specified, the same general principles prevail, *viz.*:—

1. The central conductor is a copper wire, or strand of wires.
2. The insulating covering is gutta-percha.
3. The external protection, when used, consists of hemp or other fibrous material, impregnated with pitch or some other resinous substance, nearly in all cases covered with iron or steel, more in the form of an ordinary rope.
4. The cables so prepared have been paid-out over the stern of ordinary vessels, with a pressure-break to regulate the delivery according to the speed of the vessel, which has averaged from four to six knots per hour.

In all cases copper has been chosen for the conducting wire, its durability and its high conducting power rendering it peculiarly applicable for the purpose. In the first telegraphs, the conductor generally consisted of a No. 16 copper wire. This size gave abundant area, and the resistances, even when in lengths of several miles, were

* 'The Atlantic Cable and its Teachings,' QUARTERLY JOURNAL OF SCIENCE, No. 1, p. 44.

not found to interfere seriously with the working. The conducting power of copper wire was taken to be directly as the area; there were, however, no precise data for determining *à priori* the size of wire requisite for any given length of circuit and speed of transmission. The wire was joined by being carefully lapped and soldered at the joint, and wrapped with smaller binding-wire, which was also soldered with silver solder. In spite of the utmost care in the construction of these joints, some were always imperfect, owing to their liability to fracture, and a break at any single joint destroyed the value of the whole cable. Moreover, the defects in the copper, owing to want of homogeneity, and the presence of foreign matter, frequently rendered the wire so weak that it ultimately parted after being covered, breaking the circuit, or stretched out and reduced the diameter to an inconvenient extent. It was also found that, if the covered wire was excessively stretched, and then allowed to contract, the copper wire, being incapable of regaining its original dimensions, knuckled through the elastic coating.

To remedy these defects, instead of a single copper wire bundles of smaller ones, of similar area, were adopted, the joints being so distributed that the fracture, or defect, of a single wire, does not destroy the whole cable. One serious objection to this form of conductor is that, if a single wire breaks, the sharp end is liable to penetrate through the gutta-percha, and establish a communication with the outer conductor. Such a defect is not easily detected, and it can only be guarded against by close examination of the strand itself, and by the constant testing of the coating during the manufacture. In the form of a strand the bulk of the conductor is also greater, and more gutta-percha will therefore be required to cover it. It will, moreover, not be perfectly solid, but will allow water, if it happen to penetrate to any part of the wire, to pass along as in a tube. This latter objection the Gutta-percha Company propose to remove by coating the central wire of the strand with Chatterton's Compound, and then bedding the six centre wires in it in the process of twisting. The compound squeezed out between the wires unites firmly with the insulating material, and the whole becomes so solid that a few inches of this cable will prevent the percolation of water at a pressure of 600 pounds per square inch. Mr. Daft proposes to obtain the same object by bedding copper wires coated with brass in vulcanized india-rubber. Mr. Clark obtains solidity by making the conductor in the shape of a solid wire, divided into three or four sections longitudinally, fitting closely to each other. Mr. Newall unites the several wires of a strand with solder.

Dr. Matthiesson, Professor Thompson, and other experimentalists, have shown that the quality of the copper exercises a material influence on the conducting power of the wire, and it is very important that copper, as pure as can be obtained in commerce, should be used.

The following table, extracted from the commissioners' report, shows the relative value, or conducting powers, of certain commercial coppers :—

TABLE, *showing the Conducting Power of certain Commercial Coppers.*

Quality of Copper.	Conducting Power.	Temperature Centigrade.	Cause of Diminution of Conducting Power.
		°	
Pure copper . . .	100· mean	15·5	
Specimen furnished by Mr. Tennant, cut from a piece 1½ ton in weight	98·78	15·5	Traces of silver. No suboxide of copper.
American (Lake Superior)	92·57	15·	Traces of iron, silver (·03 per cent.), and suboxide of copper.
Australian (Burra Burra)	88·86	14·	Traces of iron and suboxide of copper.
Best selected . . .	81·35	14·2	Traces of iron, nickel, antimony, suboxide of copper, &c.
Bright copper wire .	72·22	15·7	Traces of lead, iron, nickel, suboxide of copper, &c.
Tough copper . .	71·03	17·3	Traces of lead, iron, nickel, antimony, suboxide of copper, &c.
Russian (Demidoff)	59·34	12·7	Traces of iron, arsenic, nickel, suboxide of copper, &c. The arsenic present may be considered the chief reason of the low conducting power.
Spanish (Rio Tinto).	14·24	14·8	Two per cent. arsenic; traces of lead, iron, nickel, suboxide of copper, &c. The low conducting power is to be attributed to the arsenic present.
Gibraltar core:—			
Specimen, No. 112	90·7	15·5	Traces of lead, suboxide of copper, iron, and antimony.
„ „ 91	89·5	15·5	
„ „ 292	78·2	15·5	Traces of lead, arsenic (very small), iron, nickel, antimony, and suboxide of copper.
„ „ 240	74·4	15·5	

From the above table, it would appear that the difference of conducting power in the different kinds of copper is caused by the impurities contained in the specimens experimented upon. The Rio Tinto copper, in so far as regards its conducting power, being no better than iron.

It has been found that there are no alloys of copper which have a better conducting power than the metal itself; but, as perfectly pure copper is not to be obtained, we have only to reiterate that copper, as pure as can be possibly procured, is the only metal which should be used for the conducting wire of a submarine cable.

Insulation.—As copper seems to stand out prominently as the most fitting conductor, so does caoutchouc, or india-rubber, appear almost specially intended for the purpose of insulation. Its qualities, in this respect, are of the highest order. It is tough, highly elastic, of less specific gravity than water, easily manipulated, extremely durable under water, nearly impervious to moisture, except superficially, and not excessively costly; and on its first introduction it appeared as if nothing further could be desired. One of the first and most important

requirements in any insulating substance is that it should offer facilities for making the numerous joints required, either in the first construction of the line or for its repair when laid down. For this purpose, also, india-rubber appeared well adapted : if after being cut the fresh surfaces are immediately brought into contact, almost perfect reunion takes place ; and if they are warmed and slightly moistened with naphtha (in which india-rubber is soluble), they are hermetically sealed. The covering was effected by first coating the copper wire with cotton and shellac varnish, and then winding a thin strip of masticated india-rubber spirally round the wire, each turn overlapping the last. Several coatings were thus put on, the union of the surfaces being secured by means of naphtha. An almost perfect insulation was the first result, the problem on which so much time and money had been expended seemed to be definitely solved, and the new material came into rapid use. A short time, however, showed the fallacy of these hopes. India-rubber, like all other gum-resins of a similar character, slowly burns or oxidizes in the air, even in darkness; but when exposed openly to the weather and to sunlight this oxidization goes on with alarming rapidity; wires hung out of doors soon become useless; the india-rubber assumed a thick gummy or semi-fluid character, and soon fell away from the wire. The joint, even when made with naphtha, was found not to be durable, and after a short time, even in unexposed situations, the coating was found loose upon the wire. Attempts were made to preserve it by enclosing it in grooved boards, and thus protecting it from the air, but in dry situations this was found to be of but little avail; and although in wet tunnels it was found to add to the durability, it was ultimately obliged to be abandoned there also.

Gutta-percha was soon proposed as a remedy for these evils. When pure, and at moderate temperatures, it is a remarkably good insulator, and, moreover, is capable of being kneaded and drawn solidly on the wire through dies, thus avoiding the infinite number of joints required when india-rubber is used. From an analysis by Professor W. A. Miller, it appears that pure gutta-percha is a hydro-carbon, consisting of—

Carbon	88·96
Hydrogen . . .	11·04
	100·00

In commerce, however, it is mixed with resin, vegetable fibre, moisture, &c.; the latter being mechanically diffused through the mass, influencing its pliability and toughness. Commercial gutta-percha will remain unchanged for months in the air, provided light be excluded, and the temperature be not very high; and it will remain unaltered for years in water, especially if coated with Stockholm tar, and kept in the dark. It is, however, rapidly destroyed by alternated exposure to a moist and dry atmosphere, especially if the sun's rays have access to it. Professor Miller found that all the deteriorated portions had absorbed oxygen.

We have made numerous experiments upon the effect of temperature and hydrostatic pressure on both gutta-percha and caoutchouc. They necessarily occupy a very considerable time, and are otherwise difficult to perform. The general results appear to be that temperature has a very marked effect upon gutta-percha, but that pressure appears to consolidate the material and improve the insulation, of both gutta-percha and india-rubber.

The results may be briefly stated, as follows:—With the gutta-percha in ordinary use for submarine cables, the insulation at 72° Fahr. was not one half as good, and at 92° not one fourth as good, as it was at 52°, and at 52° it was not one third as good as at 32°. Perfectly pure gutta-percha was a far superior insulator, and suffered little loss of insulation, until it attained a temperature of between 72° and 92°. India-rubber and Wray's compound, which are very far superior as insulators to the gutta-percha which has been ordinarily in use, exhibit very little loss of insulating power until they attain temperatures far above 92°.

The experiments at a very high temperature showed that, whilst india-rubber withstood a heat of 200° Fahr., and Wray's compound one of 152°, gutta-percha-covered wire was entirely spoiled at a temperature a little over 122°. At 90° to 100° gutta-percha does not change its shape, but at a higher temperature a wire, when covered with this gum, easily becomes eccentric by the mere process of coiling. Gutta-percha-covered wire should in no case be exposed to heat the exact amount of which cannot be defined and regulated. The material is therefore not a desirable one for cables which have to be conveyed through, or laid in, the tropics, unless means be found for ensuring that the cable be maintained at a low temperature.

When immersed in water gutta-percha, india-rubber, Wray's compound, and Chatterton's compound, absorb a portion. Professor Miller's experiments, in which gutta-percha and india-rubber were subjected to pressure of three tons per square inch for a period of six weeks, show that the absorption of water by gutta-percha is almost *nil* in sea-water, and only trifling, though appreciable, in fresh-water. The absorption of water by caoutchouc is always sensible, the surface being rendered white and opaque. The absorption, however, only reaches to a small depth, and does not destroy, nor in any way impair, the insulating power of the subjacent portion. The white aspect disappears as the substance dries. The amount of absorption is dependent upon the extent of surface exposed to the action of the water. The insulation of specimens of gutta-percha and masticated india-rubber, experimented on by Professor Miller, was in no way impaired by immersion under pressure, but the results with virgin india-rubber were not equally satisfactory.

The experiments conducted by the writer, at Manchester, on the permeability or absorption of water under pressure, and of different degrees of temperature, give variable results, as shown in the following pages. They were instituted to determine the value of the different kinds of insulators under severe pressure, and to ascertain not only the amount of absorption under a force equivalent to the known depths of

the Atlantic, but to prove experimentally the properties which peculiarly belong to the material now in use for the purposes of insulation under the varied conditions of pressure, temperature, &c. This being the case, and as these experiments were carried to a much greater extent as regards pressure, we deem it essential to give them *in extenso*.

The following experiments were prosecuted at the request of the Commission, with a view to determine how far the different kinds of material proposed as insulating coverings for electric submarine cables were reliable when placed at the bottom of the ocean under the pressure of superincumbent water. It appears that all insulators which have been subjected to experiment absorb more or less water under pressure, even those that are closest in texture—such as vulcanized india-rubber and gutta-percha; and it seems that this absorption increases the longer the specimen is retained under water, the greater the pressure to which it is subjected, and the higher the temperature of the water in which it is immersed. The very limited time which has been available for these experiments has prevented my doing more than to indicate decisively these general facts, without determining the numerical relations of the quantities absorbed under different conditions of time, pressure, or temperature. But already the experiments point out a very important inquiry, some of the methods by which that inquiry may be prosecuted, and some of the conditions which must be attended to in order to ensure reliable and corresponding results.

Generally, in regard to insulating power, the various materials tried arrange themselves in the following order of permeability, the first absorbing least water, and the last absorbing most:—

1. Chatterton's compound.
2. Gutta-percha.
3. Masticated india-rubber.
4. Vulcanized india-rubber.
5. Carbonized india-rubber.
6. Wray's compound.
7. Unmasticated bottle india-rubber.

The experiments on the insulating power of various cores under pressure are less complete than those on absorption, and have been prosecuted under greater difficulties and with less variety of conditions.

So far as the experiments go, however, Wray's core exhibited very high insulating powers, retaining the charge longer than any other tried. Next in order to this may be placed a core of pure india-rubber coiled in two coats over a wire, but this very rapidly lost its insulating power under pressure. Then, a core of pure gutta-percha cured by the Mackintosh process; and the experiments on this are perhaps the most satisfactory of the series. The pressure was retained upon the cable for 406 hours, in which period it exhibited considerable diminution of insulation. A core of twenty alternate coats of gutta-percha and Chatterton's compound also exhibited good insulation unimpaired after 170 hours' immersion. The experiments on a core subjected to pressure in an insulating liquid before being placed in our hands gave

anomalous results. The insulation increased, instead of diminishing, as the liquid dissolved out.

The first experiments have for their object the determination of the increase of weight of various insulating materials, when subjected to enormous pressure under water. A series of insulators were selected, such as gutta-percha, india-rubber, Wray's compound, Chatterton's compound, vulcanized india-rubber, india-rubber compounded with carbon, and marine glue. Of these, suitable-sized pieces were prepared and placed in a strong steel cylinder, and subjected to pressure by means of a lever and plunger. Before their introduction into the cylinder, and whilst dry, they were carefully weighed in a delicate balance. Then, after being subjected to pressure for a shorter or longer period, as the case might be, they were again dried on the surface, and immediately weighed. The increase of weight due to the pressure under water is the measure of the quantity of water which had been absorbed, or rather forced, into the pores of the insulator.

FIG. I.

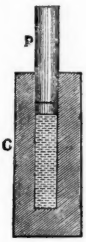


Fig. 1 represents the apparatus employed in these experiments. C is the large cylinder of steel in which the specimens were placed; P, its plunger, 2 inches diameter. Fig. 2 shows the general arrangement of the apparatus; L L, the large lever; F, its fulcrum; and P, the plunger of the cylinder C, in which the weighed specimens were placed. The plunger is guided vertically by the box B B, forming part of the general case or stand in which the lever is placed. By means of weights suspended on the extremity of the lever, the requisite pressure could be applied to the water in the cylinder C.

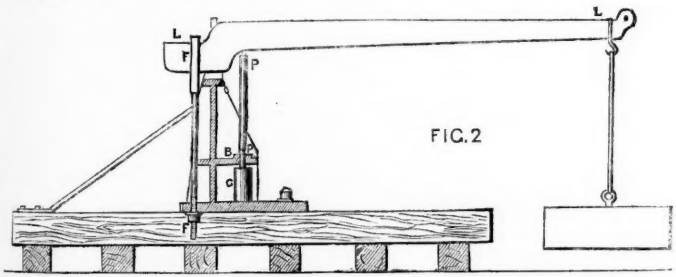


FIG. 2

The temperature in all these experiments was low, sometimes several degrees below the freezing-point. In the first experiment with Wray's compound, the cylinder when opened was found to be filled with loose ice.

In the following table the last column shows the gutta-percha to be least absorbent, and the india-rubber most so. Wray's compound absorbed more than carbonized india-rubber, but less than pure india-

TABLE I.—*First Series of Experiments on Absorption, under a Pressure of* 20,000 *lbs. per square inch, reduced to* 100 *hours' exposure and* 10 *inches area.*

Reduced results.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Area of Specimen, in sq. inches.	Water absorbed, in grains.
1	India-rubber	20,000	8·720	100	10	0·177
2	India-rubber with carbon .	20,000	8·720	100	10	0·055
3	Wray's compound . . .	20,000	8·720	100	10	0·072
4	Gutta-percha	20,000	8·720	100	10	0·044

rubber. The pure india-rubber appears to combine superficially with water as the surface becomes white, either at parts, in the present experiment, or over the whole surface. The carbon appears to prevent the formation of this hydrate, and at the same time reduces the elasticity of the native rubber, and enables it to be worked more kindly.

In the next series, the whole of the specimens were placed in the same cylinder, Fig. 1, and remained under pressure during the same period and under the same conditions.

TABLE II.—*Experiments on Absorption, under a Pressure of* 6,000 *lbs. and at the Ordinary Temperature.*

Results reduced to 10 inches area.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Area of Specimen, in sq. inches.	Water absorbed, in grains.	
1	India-rubber, unmasticated	5,900	2·575	450	10	3·075	
4	India-rubber, masticated .	5,900	2·575	450	10	0·023	
8	" " .	5,900	2·575	450	10	0·636	0·682
9	" " .	5,900	2·575	450	10	0·700	
10	" " .	5,900	2·575	450	10	0·711	
11	India-rubber, vulcanized .	5,900	2·575	450	10	0·146	
7	India-rubber, carbonized .	5,900	2·575	450	10	0·980	
2	Gutta-percha	5,900	2·575	450	10	0·378	0·307
13	" "	5,900	2·575	450	10	0·177	
14	" "	5,900	2·575	450	10	0·366	
5	Wray's compound . . .	5,900	2·575	450	10	0·750	0·725
13	" " . ; .	5,900	2·575	450	10	0·700	
6	Chatterton's compound .	5,900	2·575	450	10	0·375	0·279
12	" " .	5,900	2·575	450	10	0·183	

These tables show that, of all the substances tried, native unmasticated india-rubber absorbs by far the most water. The whole surface of the specimen had lost its black colour, and become whitened during the experiment. Taking the mean of three experiments very closely agreeing, we find that native india-rubber, after manufacture, absorbs less water than in its native state, in the proportion 0·682 to 3·07, or 1 : 4½. Vulcanized india-rubber appears to be the least absorbent substance tried, but when combined with carbon, it absorbs nearly one-third more water (according to the results in this table) than in its pure masticated state. Gutta-percha and Chatterton's compound are nearly alike in their resistance to absorption, the latter being superior. In these experiments they increased in weight only one-half as much as pure india-rubber (masticated), and twice as much as vulcanized india-rubber. Wray's compound absorbed rather more than masticated india-rubber. Marine glue lost instead of increasing its weight.

Comparing these experiments with the last, we find that these materials are far from following a law of simple proportion in the amount of water absorbed in different times. The present experiments were made under a pressure of 5,900 lbs. per square inch, and lasted for a period of 450 hours. The last were made under a pressure of 20,000 lbs., and lasted less than 100 hours. In the present experiments, carbonized india-rubber absorbed seventeen times as much as in the former; Wray's compound, ten times; gutta-percha, seven times; and masticated india-rubber, only four times. Hence it appears that, other things being equal, masticated india-rubber would be most advantageous, and carbonized india-rubber least so, as insulators; because, so far as these experiments afford data for generalizing, masticated india-rubber follows a rate of absorption diminishing most with time, and carbonized india-rubber least so. This deduction, however, is complicated by the fact of a difference of pressure, and possibly of temperature, in the two experiments.

The order of merit in resisting absorption, as derived from this series of experiments, is—

1. Vulcanized india-rubber.
2. Chatterton's compound.
3. Gutta-percha.
4. Masticated india-rubber.
5. Wray's compound.
6. Carbonized india-rubber.
7. India-rubber not masticated.

The next series of experiments was made under greater pressure, but in the same manner and for the same period of immersion.

TABLE III.—*Third Series of Experiments on Absorption, at Ordinary Temperatures.*

Reduction of results to 10 inches area.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Area of Specimen, in sq. inches.	Water absorbed, in grains.	
6	Raw india-rubber . . .	15,000	6.54	450	10	1·65	
7	Masticated india-rubber .	15,000	6·54	450	10	0·22	
8	„ „ .	15,000	6·54	450	10	0·29	0·26
9	„ „ .	15,000	6·54	450	10	0·30	
10	Carbonized india-rubber .	15,000	6·54	450	10	0·29	
5	Gutta-percha	15,000	6·54	450	10	0·18	
1	Wray's compound . . .	15,000	6·54	450	10	0·56	0·57
2	„ „ „ . . .	15,000	6·54	450	10	0·58	
3	Chatterton's compound .	15,000	6·54	450	10	0·054	0·057
4	„ . „ .	15,000	6·54	450	10	0·058	

The temperature during these experiments was generally lower than in the second series, being frequently at the freezing-point. There was loose ice in the cylinder when opened.

The higher pressures in these experiments seem to bring out more decisively the differences in the amount of absorption; but it is remarkable that, whilst the relative absorption does not widely differ, and the order of the insulators in their resistance to absorption is the same, the absolute quantity absorbed under greater pressure is less than in the previous series of experiments. The only discrepancy between the two series of experiments is the relatively low absorption of masticated india-rubber.

The order of merit, or power of resisting absorption, is in these experiments—

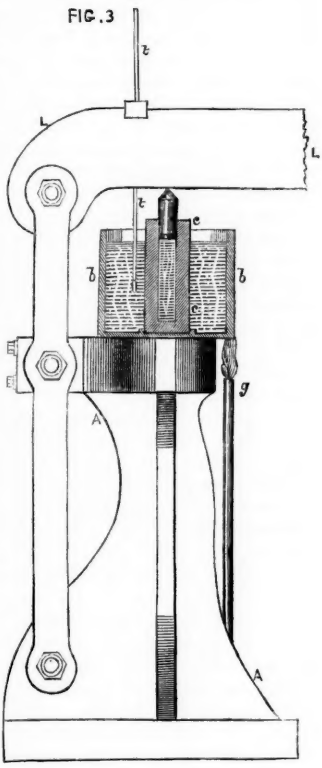
1. Chatterton's compound.
2. Gutta-percha.
3. Masticated india-rubber.
4. Carbonized india-rubber.
5. Wray's compound.
6. Raw india-rubber.

The last in this series absorbed twenty-seven times as much as the first; gutta-percha and Chatterton's compound hold, as before, the highest place, but the superiority of the latter was more manifest; it had become whitened at the surface, but apparently the water had penetrated the thinnest possible film.

The next experiments were made with a view to determine the effect of temperature on the absorption of water by these in-

sulators. Recourse was had to the small cylinder, *c*, Fig. 3, which was surrounded by the water-bath, *b*, *b*, maintained at a uniform temperature of 100° Fahr. by the gas-jet *g*. *t*, *t*, is the thermometer. The lever by which the pressure was applied to the plunger is shown at L, L, attached to the firm cast-iron base, A, A.

FIG. 3



The different substances were tried separately, as in the first series, and the weighings were repeated at intervals. During the night it was necessary to remove the gas jet, as the uniformity of temperature could not be depended upon; hence, for half the period of immersion the specimens were at a temperature of 50° only, and for the remainder at a temperature of 100°. The loss of weight, after removal from the cylinder, in consequence of the evaporation of the water absorbed, was, in these experiments, noted, and it was found the specimens decreased in weight below their original weight when dry.

In the whole of these experiments, the pressure was 20,000 lbs. per square inch; area of specimens, 8 square inches; and thickness, about one-eighth of an inch.

TABLE IV.—*Fourth Series of Experiments on Absorption, at Increased Temperatures.*

Results reduced to 100 hours and 10 inches area.

No. of Experiment.	INSULATORS.	Pressure, in lbs. per sq. inch.	Duration of Exposure, in hours.	Temperature, Fahr. (Mean).	Area of Specimen, in sq. inches.	Water absorbed, in grains.	Loss of Weight in Drying.
3	Gutta-percha	20,000	100	75°	10	0·27	3·61
4	India-rubber	20,000	100	75	10	0·45	0·87
5	Wray's compound . . .	20,000	100	75	10	0·58	0·91
6	Chatterton's compound .	20,000	100	75	10	0·20	0·60
7	Vulcanized rubber . .	20,000	100	75	10	0·80	2·27

Comparing the numbers in this table with those in the first series, which were made under precisely similar conditions in all respects, except temperature, which then did not exceed an average of 40° or 45° Fahr., it becomes evident that temperature has a considerable effect on the amount of water absorbed. Thus, gutta-percha at 45° absorbed 0·044 grains; at 75°, 0·27 grains, or six times as much. In like manner, india-rubber absorbed 0·177 grains at a lower temperature, and 0·45 at the higher, or two-and-a-half times as much. Wray's compound, 0·072 at the lower temperature, and 0·58 at the higher, or seven times as much.

Reasoning upon the foregoing experiments, a question arises as to the ratio or quantity of water absorbed in different times, and the condition of the specimens after a much more lengthened immersion. The present experiments, although showing the relative permeability of different insulators, do not afford data to determine the ultimate condition of the material intended to surround and insulate the conducting wires of the electric cable. To ascertain these facts, a much more enlarged series of experiments is required, extending over a much greater length of time. If, for example, gutta-percha absorbs ·015 grains of water in 100 hours, under a pressure of 20,000 lbs. on the square inch, we want to determine the corresponding quantity absorbed in 1,000 hours; and further, at what period will the continuous absorption cease? These are questions of vital importance as regards the porosity of the specimens; and, when ascertained, we should still require to know to what extent the insulation of the electric current would be impaired in the cable saturated with moisture.

Should our best insulators, such as Chatterton's compound or gutta-percha, as given in the experiments, arrive at a point at which they will absorb no more water under a given pressure, it then becomes necessary that we should ascertain whether the water imbibed is sufficient to carry off the whole or a part of the voltaic current, and whether the passage of the current through the insulator would accelerate, in turn, the oxidation and consequent destruction of the conductor. To solve these questions, we require, in my opinion, a long series of carefully-conducted experiments, which would tend to give a reliability to these important undertakings which at present they have not attained.

The earlier experiments on the insulating power of various cores when placed under pressure were made with voltaic electricity; but, owing to the shortness of the specimens, it was found impossible to destroy their insulation by the absorption of water so as to permit a current from a small battery to pass through the covering.

Failing in this, recourse was had to frictional electricity, which, from its high intensity, passed with greater or less facility through the insulating coverings of the wire. Still the difficulty of deciding upon the period at which, after remaining under pressure, the insulation began to grow less perfect, remained to a large extent unremoved. This difficulty was very much increased by the necessarily short period in which the experiments had to be completed. It was impossible in many cases to leave the cores long enough under pressure to ascertain

clearly the entrance of water; and only in one or two instances was any defect in the cable detected, beyond question, by the gradual loss of insulating power in the specimen under trial. To inadequacy of time were added manipulative difficulties; such as the making of a packed joint which should hold tight against so enormous a pressure as 10,000 lbs. per square inch, and also the variable hygrometric condition of the atmosphere.

The earlier and preliminary experiments were made with a simple double pith ball electrometer suspended from one of the exposed ends of the cable. This method, however, did not allow of sufficient accuracy in the measurement and regulation of the charge and the rate of loss, to afford satisfactory results.

The following method was then adopted. The core was placed in a steel cylinder, E, E (Figs. 4 and 5), with the ends projecting. This

FIG. 4

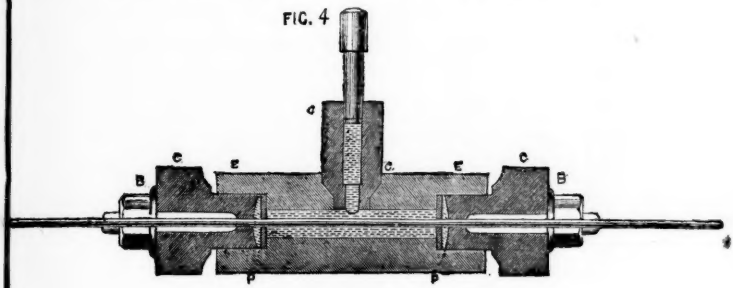
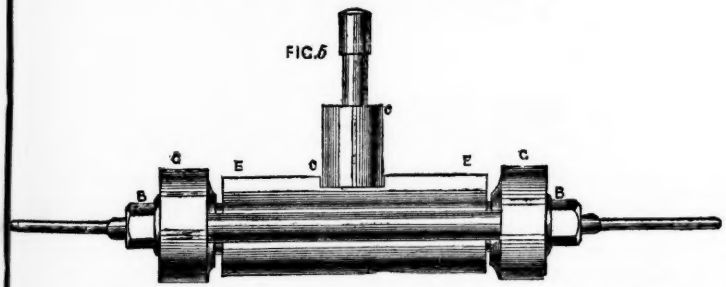


FIG. 5



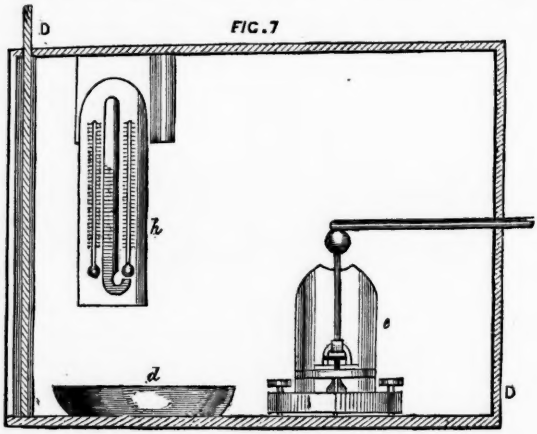
cylinder was bored out to seven-eighths of an inch diameter, and at either end a pair of strong brass glands, G, G, were fitted, so as to compress round the core the vulcanized india-rubber packing, P, P, by the aid of the bolts and nuts, B, B. The compression thus applied indented the core to a greater or less degree (Fig. 6) at each of the points where

FIG. 6.

the india-rubber packings were applied; and this indentation was greater or less according to the pliability of the insulator. Communicating with the large cylinder, E, E, is a small cylinder, C, C, fitted with a solid plunger. The pressure was applied, through the medium of the plunger, by a lever, L, L (Fig. 3), after the cylinders had been filled with water. Up to about 10,000 lbs. pressure per square inch, or a pressure equivalent to the weight of a column of water 4·36 miles high, the cylinder would stand without leakage; but beyond this pressure the water forced its way amongst the packings, and, either with or without external leakage, prevented the attainment of any higher pressure from the fall of the plunger on its bearings.

One end of the core was hermetically sealed in all but the earliest experiments. The other end was covered with a rounded brass cap, and surrounded by a closed box, D, D (Fig. 7), containing dishes, *d*, of

FIG. 7



concentrated sulphuric acid, an electrometer, *e*, and a hygrometer, *h*. By means of the acid the atmosphere round the cable was kept in a tolerably uniform condition of dryness in a room otherwise damp, and the apparatus and surface of the cable maintained under similar conditions throughout the whole of the experiment.

The electrometer employed is known as the Peltier's electrometer. In this instrument the electricity being simultaneously communicated to a fixed bar and a metallic index, the latter is repelled. A directive force is given to the index by means of a small magnetic needle, in order to retain it at zero when no electric force acts upon it.

The charge was given from an electrophorus, and was ordinarily of such intensity as to deflect the needle through an arc of 70°. The fall of the needle, from loss of charge, was then watched at intervals as nearly uniform as was convenient, until the needle had sunk to 20°.

Although interesting, it would be unnecessary to give the experi-

ments on insulation in detail, and therefore, as in the former experiments on permeability, a summary of results will suffice.

SUMMARY OF RESULTS, *showing approximately the Time required in each for a Loss of Charge equivalent to a Fall of the Electrometer Needle of 50°.*

No. of Experiment.	Description of Core.	Pressure, in lbs. per sq. inch.	Equivalent Column of Water, in miles.	Duration of Exposure, in hours.	Time required for Loss of 50°.
I.					
1, 2	Gibraltar core, cured by Mackintosh	10,000	4·363	282	136′.20″
3		10,000	4·363	328	100′. 0
4, 5		10,000	4·363	405	32′.30
II.					
1, 2, 3	Core impregnated with insulating liquid	0	0	0	6′.20″
4		10,000	4·363	24	11′.40
5, 6		10.000	4·363	48	27′.35
7		10,000	4·363	56	13′. 0
8, 9		13.000	4·363	77	62′. 0
10		10,000	4·363	120	97′. 0
11, 12, 13		10,000	4·363	170	105′. 0
III.					
1, 2	Wray's core	0	0	0	1,300′. 0″
IV.					
2	Wray's core	0	0	0	411′. 0″
V.					
2	Core impregnated with insulating liquid	10,000	4·363	4	68′.30″
3, 4		10,000	4·363	10½	44′.15
VI.					
1	Core of 20 alternate coats of gutta-percha and Chatterton's compound	0	0	0	95′ 30″
2, 3		10,000	4·363	121	42′.45
5		10,000	4 363	150	118′. 0
6		10.000	4·363	170	100′.50
VII.					
1	Core of pure india-rubber	0	0	0	443′. 0″
2		10,000	4·363	80	18′. 0
VIII.					
1, 2	Gutta-percha core	0	0	0	4′.30″
3		10,000	4·363	264	8′. 0
4, 5, 6		10,000	4·363	480	4′. 5
7, 8		10,000	4·363	576	3′.37
IX.					
1	India-rubber core	0	0	0	26′. 0″
2		3,977	1·72	390	0′. 0
X.					
1	Silver's india-rubber core	0	0	0	380′. 0″
2		0	0	0	387′. 0
3		0	0	0	382′. 0

On a careful inspection of the above summary, it will be seen that a great difference exists in the retentive powers of the different insulators under severe pressure: these anomalies almost defy attempts at comparison. If we take No. 1, the Gibraltar core, cured by Mackintosh, we have, after an immersion of 282 hours, at the enormous pressure of 10,000 lbs. per square inch, a power of retention of 136 minutes; at 325 hours' immersion, it is reduced to 100 minutes; and at 405 hours', it is still further reduced to 32 minutes, showing that the insulation is very considerably affected when a sufficiently long period of time is allowed for the permeation of the cable. In the next series of experiments, on a core impregnated with an insulating liquid, we have totally different results, as there is a steady and progressive gain in the insulating powers of the core. At 24 hours of immersion, we have 11 minutes 40 seconds; at 48 hours, 27 minutes 25 seconds; and so on till, at 170 hours, the charge is retained for a period of 105 minutes. Wray's core was too small to be fixed in the cylinder; but it retained a charge under atmospheric pressure for 1,300 minutes, and hence manifested a superiority to all the other cables tried. In another trial with a larger cable, this insulator also gave very satisfactory results. In No. 5 core, of twenty alternate coats of gutta-percha and Chatterton's compound, there are the variable results of an increase in the first five experiments from 43 minutes in 121 hours to 118 minutes in 150 hours; whilst in the sixth experiment, the retention after 170 hours' immersion again falls to 100 minutes. These discrepancies are difficult to account for, and a more lengthened series of experiments is required for the attainment of accurate results. No. 6, a core of pure india-rubber, indicated very good insulation before the pressure was applied; but after 80 hours' immersion the insulation was almost entirely destroyed.

The very important question of insulation in deeply-submerged cables is far from having received, as yet, a complete solution. The foregoing experiments are satisfactory, in so far as they show approximately the relative porosity of various materials; but they do not point out how we are to obtain an insulator impermeable to water, and at the same time a good non-conductor. This desideratum has yet to be attained.

We might have extended our illustrations on the permeability, effects of temperature, and other conditions connected with the insulators now in use; but having already enlarged the article considerably beyond the usual limits, we must conclude with observing, that in the second attempt to ensure success, as regards both the manufacture and laying of the cable, a second series of elaborate experiments had been instituted, under the direction of a scientific committee appointed for that purpose. The results of the experiments are satisfactory and interesting, but we must reserve them for a future notice, at a time when the manufacture is further advanced, and when we may confidently hope that the efforts now making on the part of the directors of the Atlantic cable will be crowned with success.

In the meantime, let us present our readers with drawings and particulars of the two cables, showing that which failed in 1858, and

that which is intended for submersion in 1865. From these will be seen the difference of weight and strength, and judging from the precautions that are now taken to have the cable retained in water-tanks, and carefully tested before immersion, we may reasonably infer that, on or before this time next year, a successful and satisfactory telegraphic communication will be permanently established between this country and the American continent.

FIG. 8.—*Cable of* 1858.

Conductor.—A copper strand, consisting of 7 wires (6 laid round 1), and weighing 107 lbs. per nautical mile.

Insulator.—Gutta-percha, laid on in three coverings, and weighing 261 lbs. per knot.

External Protection.—18 strands of charcoal iron wire, each strand composed of 7 wires (6 laid round 1), laid spirally round the core, which latter was previously padded with a serving of hemp saturated with a tar mixture. The separate wires were each 22½ gauge; the strand complete was No. 14 gauge.

Weight in Air.—20 cwt. per nautical mile.

Weight in Water.—13·4 cwt. per nautical mile, or equal to 4·85 times its weight in water per knot; that is to say, it would bear its own weight in a little less than 5 miles depth of water.

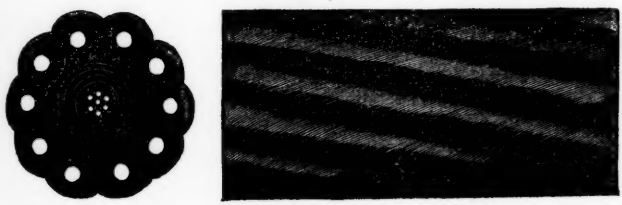
Breaking Strain.—3 tons 5 cwt.

Deepest Water to be Encountered.—2,400 fathoms, or less than 2½ nautical miles in depth.

The Contract Strain was equal to 4·85 times its weight per nautical mile in water.

One Knot, being in fathoms = 1,014 × 4 = $\frac{24170}{2400}$ = 2·05 times the strength requisite for the deepest water.

FIG. 9.—*Cable of* 1864–5.



Conductor.—Copper strand, consisting of 7 wires (6 laid round 1), and weighing 300 lbs. per nautical mile, embedded for solidity in Chatterton's Compound. Gauge of single wire, ·048 = ordinary 18 gauge. Gauge of strand, ·144 = ordinary No. 10 gauge.

Insulation.—Gutta-percha, four layers of which are laid on alternately with four thin layers of Chatterton's Compound. The weight of the entire insulation, 400 lbs. per nautical mile. Diameter of core, ·464; circumference of core, 1·392.

External Protection.—10 solid wires of the gauge 095 (No. 13 gauge) drawn

from Webster and Horsfall's homogeneous iron, each wire surrounded separately with 5 strands of Manilla yarn, saturated with a preservative compound, and the whole laid spirally around the core, which latter is padded with ordinary hemp, saturated with preservative mixture.

Weight in Air.—35 cwt. 3 qrs. per nautical mile.

Weight in Water.—14 cwt. per nautical mile, or equal to 11 times its weight in water per knot; that is to say, it will bear its own weight in 11 miles depth of water.

Breaking Strain.—7 tons 15 cwt.

Deepest Water to be Encountered.—2,400 fathoms, or less than 2½ nautical miles in depth.

The Contract Strain is equal to 11 times its weight per nautical mile in water.

One Knot, being in fathoms = 1,014 × 11 = $\frac{11154}{2400}$ 4·64 times the strength requisite for the deepest water.

ON THE PROPORTIONAL NUMBERS OF THE ELEMENTS.

By William Odling, M.B., F.R.S.

Upon arranging the atomic weights or proportional numbers of the sixty or so recognized elements in the order of their several magnitudes, we observe a marked continuity in the resulting arithmetical series, the only exceptions to the very gradual increase in value of the consecutive terms being manifested between the numbers 40 and 50, 65 and 75, 96 and 104, 138 and 184, 184 and 195, and 210 and 231·5, thus:—

H	1	Hydrogen.	Fe	56	Iron.	Cd	112	Cadmium.
L	7	Lithium.	Co	59	Cobalt.	Sn	118	Tin.
G	9	Glucinum.	Ni	59	Nickel.	U	120	Uranium.
B	11	Boron.	Cu	63·5	Copper.	Sb	122	Antimony.
C	12	Carbon.	Yt	64	Yttrium.	I	127	Iodine.
N	14	Nitrogen.	Zn	65	Zinc.	Te	129	Tellurium.
O	16	Oxygen.	As	75	Arsenic.	Cs	133	Cæsium.
F	19	Fluorine.	Se	79·5	Selenium.	Ba	137	Barium.
Na	23	Sodium.	Br	80	Bromine.	V	137	Vanadium.
Mg	24	Magnesium.	Rb	85	Rubidium.	Ta	138	Tantalum.
Al	27·5	Aluminium.	Sr	87·5	Strontium.	W	184	Tungsten.
Si	28	Silicon.	Zr	89·5	Zirconium.	Cb	195	Niobium.
P	31	Phosphorus.	Ce	92	Cerium.	Au	196·5	Gold.
S	32	Sulphur.	La	92	Lanthanum.	Pt	197	Platinum.
Cl	35·5	Chlorine.	Dy	96	Dydymum.	Ir	197	Iridium.
K	39	Potassium.	Mo	96	Molybdenum.	Os	199	Osmium.
Ca	40	Calcium.	Ro	104	Rhodium.	Hg	200	Mercury.
Ti	50	Titanium.	Ru	104	Ruthenium.	Tl	203	Thallium.
Cr	52·5	Chromium.	Pd	106·5	Palladium.	Pb	207	Lead.
Mn	55	Manganese,	Ag	108	Silver.	Bi	210	Bismuth.
						Th	231·5	Thorinum.

With what ease this purely arithmetical seriation may be made to accord with a horizontal arrangement of the elements according to their usually received groupings, is shown in the following table, in the first three columns of which the numerical sequence is perfect, while in the other two the irregularities are but very few and trivial:—

			Ro 104	Pt 197
			Ru 104	Ir 197
			Pt 106·5	Os 199
H 1	„	„	Ag 108	Au 196·5
„	„	Zn 65	Cd 112	Hg 200
L 7	„	„	„	Tl 203
G 9	„	„	„	Pb 207
B 11	Al 27·5	„	U 120	„
C 12	Si 28	„	Sn 118	„
N 14	P 31	As 75	Sb 122	Bi 210
O 16	S 32	Se 79·5	Te 129	„
F 19	Cl 35·5	Br 80	I 127	„
Na 23	K 39	Rb 85	Cs 133	„
Mg 24	Ca 40	Sr 87·5	Ba 137	„
	Ti 50	Zr 89·5	Ta 138	Th 231·5
	„	Ce 92	„	
	Cr 52·5	Mo 96	V 137	
	Mn 55		W 184	
	Fe 56			
	Co 59			
	Ni 59			
	Cu 63·5			

If we compare together certain pairs of more or less analogous elements, we find in a considerable number of instances, embracing one-half the entire number of elements, a difference in atomic weight ranging from 84·5 to 97, as shown in the following table:—

I	–	Cl	or	127	–	35·5	= 91·5
Au	–	Ag		296·5	–	108	= 88·5
Ag	–	Na		108	–	23	= 85
Cs	–	K		133	–	39	= 94
Te	–	S		129	–	32	= 97
W	–	Mo		184	–	96	= 88
V	–	Cr		137	–	52·5	= 84·5
Hg	–	Cd		200	–	112	= 88
Cd	–	Mg		112	–	24	= 88
Ba	–	Ca		137	–	40	= 97
Bi	–	Sb		210	–	122	= 88
Sb	–	P		122	–	31	= 91
U	–	Al		120	–	27·5	= 92·5
Pb	–	Sn		207	–	118·5	= 88·5
Sn	–	Si		118·5	–	28	= 90·5
Ta	–	Ti		138	–	50	= 88
Pt	–	Ro		197	–	104	= 93
Os	–	Pd		199	–	106·5	= 92·5

In about one-half of the above instances, the two elements associated with one another, are known to be the first and third terms respectively of certain triplet families; and the discovery of intermediate elements in the case of some or all of the other pairs, is not by any means improbable. Consequent upon the existence of these triplet groups, we have a considerable number of pairs of elements, also including more than one-half the entire number of elements, in which the average difference of atomic weight is about half as great as the average difference between the previously cited pairs, thus:—

I	–	Br	or	127	–	80	= 47	or	48
Br	–	Cl		80	–	35·5	= 44·5		44
Cs	–	Rb		133	–	85	= 48		48
Rb	–	K		85	–	39	= 46		48?
Te	–	Se		129	–	80	= 49		48
Se	–	S		80	–	32	= 48		48
W	–	V		184	–	137	= 48		48
V	–	Mo		137	–	96	= 41		40
Mo	–	Cr		96	–	52·5	= 43·5		44
Cd	–	Zn		112	–	65	= 47		48
Zn	–	Mg		65	–	24	= 41		40
Ba	–	Sr		137	–	87·5	= 49·5		48
Sr	–	Ca		87·5	–	40	= 47·5		48
Sb	–	As		122	–	75	= 47		48
As	–	P		75	–	31	= 44		44
Ta	–	Zr		138	–	89·5	= 48·5		48
Zr	–	Ti		89·5	–	50	= 39·5		40

At present there seems no reason to anticipate the existence of an intermediate term between any one of these pairs of elements.

In ten instances we find that more or less analogous elements have a difference in atomic weight of 16, or something approximating

closely thereto; and in seven of these instances, the element of lowest atomic weight is the first member, and the element compared therewith the second member of the group to which they both belong, or may be considered to belong, as shown in the following table, which includes nearly one-third of the entire number of elements:—

Cl	–	F	or	35·5	– 19	= 16·5
K	–	Na		39	– 23	= 16
Na	–	L		23	– 7	= 16
Mo	–	Se		96	– 80	= 16
S	–	O		32	– 16	= 16
Ca	–	Mg		40	– 24	= 16
Mg	–	G		24	– 9	= 15
P	–	N		31	– 14	= 17
Al	–	B		27·5	– 11	= 16·5
Si	–	C		28	– 12	= 16

In looking over the above tables, we can scarcely help noticing that those elements whose resemblance to one another is most pronounced, have a difference of about 48 between their respective atomic weights, that is to say, the largest difference in atomic weight known to exist between what are conceived to be proximate elements, as shown in the following table, which also includes nearly one-third of the entire number of elements. For example, the resemblance of cadmium to zinc, where the difference in atomic weight is 47, is greater than the resemblance of zinc to magnesium, where the difference is 41; while the resemblance of antimony to arsenic, where the difference is again 47, is greater than the resemblance of arsenic to phosphorus, where the difference is 44. Moreover, the co-resemblances of cæsium, rubidium, and potassium, and of barium, strontium, and calcium, with a common difference of about 48 between the proximate members, are far closer than the co-resemblances of potassium and sodium, and of calcium and magnesium respectively, with a difference of 16 in each instance:—

„				Zn	65	+ 47	Cd	112		„	
„				As	75	+ 47	Sb	122		„	
„				Br	80	+ 47	I	127		„	
S	32	+	48	Se	80	+ 49	Te	129		„	
K	39	+	46	Rb	85	+ 48	Cs	133		„	
Ca	40	+	47·5	Sr	87·5	+ 49·5	Ba	137		„	
„				Zr	39·5	+ 48·5	Ta	138		„	
„				„			V	137	+ 48	W	184

If we consider the analogous elements having a difference of about 48 in their respective atomic weights, to stand upon the same level, we may represent those with a difference of 44 or 40 as standing one or two stages above or below the level, as shown in the next table:—

Monads.	Dif. 4 F 19	„ Cl 35·5	Br 80 „	I 127 „		
	Dif. 12 L 7 Dif. 16 —	„ Na 23 K 39	„ „ Rb 85	Ag 108 „ Cs 133		Au 196·5 Tl 203 „
Dyads.	O 16 Dif. 8 Dif. 8 Dif. 4	S 32 „ „ Cr 52·5	Se 80 „ Mo 96 „	Te 129 V 137 „ „	„ W 184 „ „	
	Dif. 8 G 9 Dif. 16	„ Mg 24 Ca 40	Zn 65 „ Sr 87·5	Cd 112 „ Ba 137		Hg 200 Pb 207 „
Triads.	Dif. 4 N 14	„ P 31	As 75 „	Sb 122 „		Bi 210 „
	Dif. 4 B 11 Dif. 16	„ Al 27·5 „	„ „ Ce 92	U 120 „ „		
Tetrads.	Dif. 8 C 12 Dif. 12 Dif. 8	„ Si 28 „ Ti 50	„ „ Zr 89·5 „	Sn 118 „ Ta 138 „	„ „ „ Cb 195*	 „ Th. 231·5

By a slight modification of the above table, the occupants of similar positions in different groups, having nearly the same

* The analysis of niobic chloride by H. Rose gives 195, while the determination of its vapour density by Deville and Troost gives 173 for the atomic weight of niobium, the mean being 184.

atomic weights, may be brought into association with one another, thus :—

„	„	Ag 108	Au 196·5
„	Zn 65	Cd 112	Hg 200
Na 23	„	„	Tl 203
Mg 24	„	„	Pb 207
„	„	Sn 118	„
Al 27·5	„	U 120	„
„	As 75	Sb 122	Bi 210
Si 28	„	„	„
P 31	„	„	„
S 32	Se 79·5	Te 129	„
„	Br 80	I 127	„
Cl 35·5	„	„	„
K 39	Rb 85	Cs 133	„
„	„	V 137	„
Ca 40	Sr 87·5	Ba 137	„
„	Zr 89·5	Ta 138	„
„	Ce 92	„	„
„	Mo 96	„	„
Ti 50	„	„	Th 231·5
Cr 52·5	„	„	„

The parallelism between the monatomic and diatomic alkaline groups, is shown still more strikingly below :—

	Dif. 1.	Dif. 2.	Dif. 4.	Dif. 4.
	„	*X* 63	Ag 108	Au 196·5
	„	Zn 65	Cd 112	Hg 200
Dif. 8				
L 7	Na 23	„	„	Tl 203
G 9	Mg 24	„	„	Pb 207
Dif. 16				
	K 39	Rb 85	Cs 133	„
	Ca 40	Sr 87·5	Ba 137	„

Seeing the large number of instances in which the atomic weights of proximate elements differ from one another by 48, or 44, or 40, or 16, we cannot help looking wistfully at the number 4, as embodying somehow or other the unit of a common difference, especially when we find in addition that several pairs of strictly analogous elements differ in atomic weight by this same number, as shown below :—

Fe – Cr	or 56 – 52·5	= 3·5
Co – Mn	or 59 – 55	= 4
Cu – Ni	or 63·5 – 59	= 4·5
Dy – Ce	or 96 – 92	= 4

But on the other hand it must be borne in mind that the differences between the several atomic weights compared with one another, are for the most part not exactly but only approximately multiples of 4; whilst in a few instances, at any rate, the approximate difference in atomic weight between closely allied elements, is not 4 or some multiple of 4, but 2 or some odd multiple of 2, and in other instances even 1 or 0.

Since many of the elements occupying analogous positions in different groups have closely approximating atomic weights, it is evident that the mere determination of the atomic weight of a newly-discovered element assists us but very little in deciding to what group it belongs, but only indicates its position in the group; since among the members of every well-defined group the sequence of properties and sequence of atomic weights are strictly parallel to one another.

Doubtless some of the arithmetical relations exemplified in the foregoing tables and remarks are simply accidental; but taken altogether, they are too numerous and decided not to depend upon some hitherto unrecognized general law.

ON THE BUTTERFLIES OF MADAGASCAR.

By Roland Trimen (Cape Town), Memb. Ent. Soc. Lond.

In the belief that a brief consideration of the Rhopalocera inhabiting Madagascar may in some degree aid in the investigation of the relations of the general fauna of the island to that of Africa, which has been so ably commenced by Dr. Sclater,* I have drawn up the following notes. I must at the outset express my regret that the materials at my disposal have been too scanty to admit of the preparation of a paper affording a complete view of the subject under discussion; but it is hoped that these few remarks may prove of service to those who have access to ample means of pursuing the inquiry. I would observe, however, that the data and observations here given are, for the greater part, the results of some years' study of the butterflies of Southern Africa. My obligations to Dr. Boisduval's admirable work, the 'Faune Entomologique de Madagascar, Bourbon et Maurice,'† are too manifest to require comment.

The total number of butterflies known to me as inhabiting Madagascar (exclusive of the Mascarene Islands) is 73. These 73 species are comprised in 34 genera, and belong to the following 11 families, *viz.* :‡—*Papilionidæ*, *Pieridæ*, *Danaidæ*, *Acræidæ*, *Nymphalidæ*, *Satyridæ*, *Eurytelidæ*, *Libytheidæ*, *Erycinidæ*, *Lycænidæ*, and *Hesperidæ*.

* "The Mammals of Madagascar," in 'Quarterly Journal of Science,' No. 2, April, 1864.

† Paris, 1833.

‡ I follow the arrangement of Messrs. Doubleday and Westwood's 'Genera of Diurnal Lepidoptera.'

All these families are represented in Africa. The four families which, it appears, are not represented in Madagascar are also wanting on the African continent, and are these, *viz.*:—The *Ageronidæ*, *Heliconidæ*, and *Brassolidæ*, which are confined to the New World; and the *Morphidæ*, which, though chiefly American, are represented in Asia by several species.

It will, perhaps, more clearly exhibit the close connection between the continental and insular Rhopalocera if, at the risk of wearying the reader with details, the genera and species of each Madagascarian family are briefly considered in regular order.

The PAPILIONIDÆ, a family which, though poor in generic forms, is numerous in species and of world-wide distribution, are represented by six species of the genus *Papilio*, if we include the doubtfully distinct *P. Epiphorbas*, which Boisduval himself considers "pourroit bien n'être qu'une modification locale" of the Mauritian *P. Phorbanta*, Linn.,* and if *P. Nireus*, Linn., be truly a native. The last-named species, *P. Merope*, Cram., and *P. Demoleus*, Linn., range over the greater part of Africa, extending to Sierra Leone; *Lalandei*, Godt., inhabits South Africa; and the splendid *Antenor*, Drury, taken by Mr. E. L. Layard, on the north-west coast of Madagascar, is recorded by both Boisduval† and Westwood‡ as a native of tropical Africa, a specimen in the Hopeian Collection having been received from Timbuctoo.

The PIERIDÆ include the four genera *Pontia*, *Pieris*, *Anthocharis*, and *Terias*, comprising in all nine species: *Pontia syvicola*, Bd. (= *Narica*, Fab. = *Alcesta*, Cram.), ranges to Senegal. Of the genus *Pieris*, one species, *Helcida*, Bd.,—if not a variety of the African *Chloris*, Fab.,—is endemic; *Phileris*, Bd., is found in Southern and Eastern Africa; *Orbona* and *Malatha*, Bd. (= *Saba*, Fab.), in Eastern and Western Africa; while the abundant *Mesentina* extends from Damara Land to Bengal. *Anthocharis Evanthe*, Bd., is among the species taken in Madagascar by Mr. Layard; and a specimen in the British Museum purports to be from "South Africa," but this *habitat* seems doubtful. The three species of *Terias* are all African; but while *Floricola*, Bd. (= *Hecabe*, Linn.), ranges to Java and Northern India, and *Pulchella*, Bd. (= *Rahel*, Fab.), is found at Sierra Leone, *Desjardinsii*, Bd., does not appear to spread farther than the Eastern and Southern coasts of Africa.

But one of the recorded three genera and four species of the family DANAIDÆ is found in Africa, and that one, *Danais Chrysippus*, Linn., is everywhere abundant, and is also common in Southern Asia. *Hestia Lyncea*, Drury, inhabits the Eastern Archipelago; but *Euplœa Phœdone* and *Euphone*, Fab., appear to be limited in range to Madagascar and Mauritius.

The slow-flying, inert, but abundant butterflies forming the family ACRŒIDÆ are pre-eminently African, though a few representatives of

* 'Faune Ent. de Mad., &c.,' p. 13. *Epiphorbas* and *Phorbanta* are almost certainly but insular varieties of the widely-ranging and abundant *P. Nireus*, which Boisduval (*op. cit.*, p. 16) considers a doubtful native of Madagascar.

† 'Species Général des Lep.,' p. 190.

‡ 'Arcana Entomologica,' vol. i., p. 146.

the group are American, two species Asiatic, and one Australian. As many as ten species of *Acræa* (the only genus in the family) have been taken in Madagascar, and of these no less than six appear peculiar to the island. The four found in Africa are *Sganzini*, Bd. (= *Lycia*, Fab.), and *Manjaca* Bd. (= *Serena*, Fab.), extending to Sierra Leone, and the South African *Rahira*, Bd., and *Punctatissima*, Bd.

Ten genera of the NYMPHALIDÆ are represented, *viz.*:—*Atella* (1 species), *Pyrameis* (1), *Junonia* (5), *Myscelia* (1), *Cyrestis* (1), *Neptis* (3), *Diadema* (2), *Godartia* (1), *Aterica* (1), *Nymphalis* (1). *Atella Phalanta*, Dru., inhabits a wide region, from Sierra Leone to Northern India and Java. The world-wide distribution of *Pyrameis Cardui*, Linn., is well known. Two species of *Junonia* seem endemic, *viz.*—*Gondotii* and *Andremiaja*, Bd.; *J. Augustina*, Bd., occurs in Mauritius and Bourbon; *Rhadama* is found in Mozambique;* and *Epiclelia*, Bd. (= var. *Clelia*, Cram.), is a widely-spread African. *Myscelia Madagascariensis*, Bd., is peculiar to the island. *Cyrestis elegans*, Bd., must also be classed among the endemic insects, unless the species stated by Chenu† to inhabit Sierra Leone should prove to be identical with it. *Neptis Kikideli*, Bd., does not appear to have been met with out of Madagascar, but *N. Frobenia*, Fab., extends to Mauritius; and *Saclava*, Bd., is found both in Mozambique‡ and in the Cape Colony. Of the two *Diademæ*, *Bolina*, Linn., has an extraordinary range, only second to that of *P. Cardui*; while *Dubia*, Palis. de Beauv.,§ is recorded from both Eastern and Western Africa. The genus *Godartia* is represented in Eastern and Western Africa,‖ but *G. Madagascariensis*, Lucas, does not seem to extend beyond the island. *Aterica Rabena*, Bd., is likewise an endemic species. *Nymphalis Candiope*, Godt., taken by Mr. Layard on the north-west coast of Madagascar, inhabits the country west of Lake Ngami, from whence a specimen was brought me by Mr. John A. Bell.

The SATYRIDÆ would appear to be but poorly represented in the island, only four species, belonging to the genera *Cyllo*, *Erebia*, and *Mycalesis*, being recorded in the 'Faune Entomologique,' &c. *Cyllo Leda*, Linn., almost rivals *Diadema Bolina* in its area of distribution; but *C. Betsimena*, Bd. (if not, as I am inclined to think, identical with *Gnophodis Parmeno*, E. Doubl.), is confined to Madagascar. *Erebia Tamatavæ*, Bd., is endemic. *Mycalesis Narcissus*, Fab., extends to the Mascarene Islands as well as to South-eastern Africa.

Two butterflies of the small family EURYTELIDÆ have been discovered in Madagascar, *viz.*:—*Eurytela Dryope*, Cram., and *Hypanis Anvatara*, Bd. (= var. *Ilithyia*, Dru.). Both of these are widely-spread Africans, and the latter species also ranges to Southern Asia.

The curious LIBYTHEIDÆ are represented by the very distinct *Libythea fulgurata*, Bd., which seems more nearly related to the Javanese

* See Hopffer in Peters' 'Reise nach Mossambique.—Ins.,' p. 380.

† 'Encyc. d'Hist. Nat.—Pap.,' p. 125.

‡ Hopffer's *Neptis Marpessa* is indubitably the same insect.

§ Probably the same as *D. Anthedon*, E. Doubl. ('Gen. Diurn. Lep.'), which inhabits Western Africa and Natal.

‖ See Chenu, *op. cit.*, p. 137; and Hpfr.—Peters' 'Reise, &c.,' p. 386.

L. Narina, Godt., than to any other species. As the genus is found on the African continent,* it is not improbable that *Fulgurata* will be discovered there.

One example of the ERYCINIDÆ—a family abundantly developed in South America—has been found in the island, *viz.*—*Emesis Tepahi*, Bd. This insect seems more strictly referable to the genus *Taxila*, E. Doubl., which comprises several Oriental, and one, if not two, African species,—*T. Tantalus*, Bd., being a native of Ashanti,† and *Baucis*, Dru. (mentioned by Boisduval as congeneric with *Tepahi*) being recorded by Drury as inhabiting Sierra Leone.

The eight species of LYCÆNIDÆ known to occur belong to the genera *Sithon* (1), *Lycæna* (6), and ———? (1). *Sithon Batikeli*, Bd. sp. (= *Sithon Antalus*, Hpffr.), is found in Eastern and Southern Africa.‡ Of the *Lycænæ* three—*L. Rabe*, *Tsiphana*, and *Malathana*, Bd.—seem endemic; but the remaining three—*Lysimon*, Hübn., *Bœtica*, Linn., and *Telicanus*, Herbet—are remarkable for their extended range throughout Africa, and in Southern Europe and Asia. It is impossible to refer the species *Tintinga*, Bd., to any particular genus, the single specimen described by Boisduval having lost both head and body; but, as its describer seems to consider that the insect has somewhat of the aspect of the curious Javanese *Petavius*, Godt. (= *Petavia Sakuni*, Horsf.), its affinities are probably Oriental rather than African.

The HESPERIDÆ, as recorded by Boisduval, consist of 11 species, which I distribute generically thus, *viz.*:—*Cyclopides* (3), *Pamphila* (4), *Nisoniades* (1), *Ismene* (3), *Cyclopides Bernieri* and *Rhadama*, Bd., appear peculiar to Madagascar; but *C. Malgacha*, Bd., is found in Africa, as far south and west as Cape Town. *Pamphila Havei* and *Pontieri*, Bd., are recorded by Boisduval§ as natives of Natal, while *P. Coroller* and *Andracne*, Bd., are endemic. I have received *Nisoniades Ophion*, Dru., from Natal, and the species is figured and described by Drury as one from Western Africa. *Ismene Florestan*, Cram., has an African range, embracing Kaffraria, Querimba, Nubia, and Senegal;‖ *I. Ratek*, Bd., inhabits Natal; and *I. Ramanatek*, Bd., extends to Bourbon, if not to Mauritius.

The above particulars of the distribution over the globe of the Madagascarian diurnal Lepidoptera yield the following result, when the families are tabulated (see p. 652) :—

From this table it is apparent that 39, or rather more than half, of the butterflies of Madagascar are African; and of these 39 species, 27 (nearly one-third of the Rhopalocerous Fauna) inhabit no other region besides Africa. Of the remaining 34 (no less than 28 of which are endemic), 1 (*Hestia Lyncea*) is an Asiatic form; 22 show

* For this fact I am indebted to Mr. Horace Waller, of the late Zambesi Mission, who has shown me a *Libythea*, closely allied to *L. Myrrha*, Godt., taken by him on the river Shirè.

† E. Doubl., 'List Lep. Ins., Coll. Brit. Mus.,' pt. ii., p. 3.

‡ *Batikeli* will most probably be determined as a variety of *Isocrates*, Fab., a well-known Indian species.

§ In Appendix to Delegorgue's 'Voyage dans l'Afrique Australe, &c.,' p. 594.

‖ See Hpfr., *op. cit.*, p. 414.

TABULAR VIEW OF THE GEOGRAPHICAL DISTRIBUTION OF THE BUTTERFLIES OF MADAGASCAR.

FAMILIES.	NUMBER OF ENDEMIC SPECIES.	NUMBER OF SPECIES WHOSE RANGE EXTENDS TO										TOTAL NUMBER OF SPECIES INHABITING MADAGASCAR.
		Africa only.	Mascarene Islands only.	Asia only.	Africa and Mascarene Islands.	Africa and Asia.	Africa, Mascarene Islands, and Asia.	Africa, Mascarene Islands, Asia, and Europe.	Africa, Mascarene Islands, Asia, and Australia.	Africa, Mascarene Islands, Asia, Australia, and America.	Cosmopolitan.	
Papilionidæ .	1	5	—	—	—	—	—	—	—	—	—	6
Pieridæ . .	2	5	—	—	—	1	1	—	—	—	—	9
Danaidæ . .	—	—	2	1	—	—	—	1	—	—	—	4
Acræidæ . .	6	4	—	—	—	—	—	—	—	—	—	10
Nymphalidæ.	7	5	2	—	—	—	1	—	—	1	1	17
Satyridæ . .	2	—	—	—	1	—	—	—	1	—	—	4
Eurytelidæ .	—	1	—	—	—	1	—	—	—	—	—	2
Libytheidæ .	1	—	—	—	—	—	—	—	—	—	—	1
Erycinidæ .	1	—	—	—	—	—	—	—	—	—	—	1
Lycænidæ. .	4	1	—	—	—	—	—	3	—	—	—	8
Hesperidæ .	4	6	1	—	—	—	—	—	—	—	—	11
11	28	27	5	1	1	2	2	4	1	1	1	73

decidedly African affinities; 4 (*Neptis Kikideli* and *Frobenia*, *Libythea fulgurata*, and ———? *Tintinga*) seem more nearly allied to Asiatic forms; while 7 exhibit no marked indications of connection with either Asiatic or African types, but may be considered as being equally related to both faunas.* The respective numbers of species inhabiting other parts of the world are, relatively to the total number of Madagascarian natives and to each other, quite what we should expect to find on the assumption that Madagascar was originally part of the great continent to which it is now adjacent. Thus while, as above shown, no less than 39 inhabit Africa, the Mascarene Islands contain 15, Asia 12, Europe 5, Australia 2, and America 2.

Before concluding, it is necessary to take into consideration the Rhopalocera inhabiting Bourbon and Mauritius, amounting in all to but 23 species. As these islands are of small size, and have been well explored, we may assume with Boisduval that few butterflies remain in either undiscovered. The 23 species are thus distributed among the

* The most remarkable examples of this double relation are the two *Euplææ*, *E. Euphone* and *Phædone*, which, common at Mauritius and also found in Madagascar, combine the structure and aspect of the African Euplæoid species of *Danais* with those of the true *Euplææ* of Asia. An examination of these insects has led me to regard as highly probable the view suggested to me by Mr. Bates, that the Mascarene Islands may be remnants of the region where *Danais* and *Euplæa* first became differentiated; *Euplæa* since attaining its large development in tropical Asia. It is singular that *Euplæa Gondotii*, Bd., which inhabits both Natal and the Island of Bourbon, and seems the nearest of all the African *Danaidæ* to the Asiatic *Euplææ*, has not been taken either in Madagascar or Mauritius.

families, *viz.*:—Papilionidæ, 2; Pieridæ, 1; Danaidæ, 4; Nymphalidæ, 7; Satyridæ, 2; Lycænidæ, 3; Hesperidæ, 4. In Mauritius 21 occur, in Bourbon 18; 16 being found in both islands. All but 8 are known to inhabit Madagascar:* and of these 8 species 4 (*Pyrameis Hippomene*, Bd., *Neptis Dumetorum*, Bd., *Nisoniades Sabadius*, and *Pamphila Borbonica*, Bd.) occur in both islands; 2 (*Papilio disparilis* and *Euplæa Gondotii*, Bd.) are confined to Bourbon; while 2 (*P. Phorbanta*, Linn., and *Pamphila Marchalii*, Bd.) seem peculiar to Mauritius. *Gondotii* (of Bourbon) and *Hippomene*, *Sabadius*, and *Borbonica* (of both islands) are natives of Africa, and therefore in all probability inhabit the great intermediate country of Madagascar. This leaves us but 4 species truly endemic to the Mascarene Islands, or, omitting the 2 doubtfully distinct *Papiliones*,† only 2, *viz.*—*Neptis Dumetorum*‡ and *Pamphila Marchalii*, the latter being confined to Mauritius. Besides these 2, only 5 others (which are found in Madagascar) are wanting in Africa.

Adding to the 73 butterflies of Madagascar the 8 Mascarene species not yet discovered in the great island, we arrive at a total for the group of 81 species of Diurnal Lepidoptera, of which 47 are known to be natives of Africa, while the great majority of the remaining species exhibit unmistakable affinity to African forms.

The evidence here brought forward, incomplete as it is, and limited in its application to but part of a single order of insects, contrasts strangely indeed with that adduced by Dr. Sclater with regard to the Mammals of Madagascar. Every order of Mammalia in the island possessing more than a single representative (the bats only excepted), presents *several endemic genera*, some of which exhibit the most profound modification of structure. Among the Lepidopterous insects, as far as the Rhopalocera are concerned,§ not one new genus has been discovered. While the relations between the Mammals of Madagascar and Africa are shown to be few and remote, and not one species is with certainty known to inhabit both regions, the very strongest affinity exists between the butterflies, more than half of the insular species, and 31 of the 33 genera, being indigenous to Africa.‖ This seems the more remarkable when one considers the much greater facilities for modification, during an equal lapse of time, which insects, numerous in individuals and rapid in succession of generations, would appear to present as contrasted with the comparatively scarce and slowly-

* This supposes *P. Phorbanta* and *disparilis* to be distinct species from each other and from *P. Nireus* and *Epiphorbas*; otherwise the number would be 6.

† The abnormal coloration of the ♀ *Disparilis* is very remarkable, and looks very like a modification, now in progress, of the *Papilio* in imitation of *Euplæa Gondotii*, the only other large butterfly inhabiting Bourbon.

‡ Taken by Mr. Layard in Mauritius.

§ Almost the same might be affirmed of the whole order, for of the 35 genera of Heterocera given in the 'Faune de Mad., &c.,' only one, *Borocera*, Bd. (closely allied to the African *Megasomæ*), appears endemic, unless *Sindris*, Bd. (given as a genus of Tineina), be peculiar to the island.

‖ In connection with this it is an interesting fact that *Acræa*, so typical and highly-developed an African group, presents more species in Madagascar than any other genus.

breeding Mammals. It is true that butterflies might continue to find their way from Africa to the island across a space of sea which had long since proved an impassable barrier to any but aërial Mammalia, but the influence which might thus be at intervals brought to bear on the insular Rhopalocera would be very slight, for the idea of constant or long-continued migration from the mainland is forbidden by all recent observation.*

In conclusion, I would earnestly request all zoologists to contribute the results of their researches towards the more complete knowledge of the fauna of Madagascar. Dr. Sclater's interesting deductions from a consideration of the Mammalia, require abundant confirmation from investigation of other groups in the island fauna, before acceptance can be given to them. The subject is one of the deepest interest; and it is only by a careful analysis of what is known of all the forms of Madagascarian life that we can attain to any conclusions as to the original derivation and existing relations of this most remarkable fauna.

* It is remarkable how constant nearly all butterflies, including those of the highest powers of flight, are to localities of very limited extent; and much care and investigation must be exercised before naturalists can attribute the extraordinary gatherings, occasionally witnessed, of certain species of *Pieridæ* to any migratory instinct.

CHRONICLES OF SCIENCE.

1. AGRICULTURE.

An unusually dry summer has brought into prominence several agricultural topics of importance, in which the uses and economy of water are concerned. Thus, it has entirely justified those who advocate drainage and deep tillage as really conservative of the water supply on which a growing plant depends. We have dug in well-drained land a hole five feet deep in a turnip-field, and from the bottom of it clods of earth have been brought up full of fibres of the turnip-root, easily recognizable by their taste. These fibres went far below the artificial drainage of the subsoil; but the vigorous vitality to which such deep growth was due was itself, no doubt, owing to the wholesome condition for the plants in which that drainage had placed the upper layer of soil. In this indirect way, as well as by the direct improvement and increased capacity as a storeroom which drainage and deep tillage confer upon the upper soil, do these operations increase the ability of plants to withstand a drought. That of the past summer has in nothing shown itself more plainly than in the prominent appearance of the dark, fresh green of deep-rooted plants, as the thistle and the clover plant, amongst the brown parched, surface-feeding grasses, which have been soon dried up. And anything which gives to cultivated plants a deeper, larger, fuller store on which to draw for supplies, is in cases like the present season especially beneficial.

No doubt it is owing to this better tillage of the country generally, that the drought has not proved more injurious to the seed crops of the past harvest. Notwithstanding that our grain crops had already pretty fully established themselves before the commencement of the dry weather, we might fairly have expected it to have been more injurious than it has proved. The produce of these crops, though nothing like that of 1863, has not been altogether unsatisfactory. Of 200 returns to the 'Agricultural Gazette,' indeed, from different parts of the country, only 20, 47, and 12 respectively, of wheat, barley, and oats, declare the crop to be above an average one; but one-half of the reports of wheat, and more than one-half of those of barley, state the yield to be an average. Oats, beans, and peas are undoubtedly much below an average yield this year. But this, and the inferior produce generally of the corn crop, may be attributed rather to the cold weather of June, than to the drought of May, June, and July.

The subject of summer irrigation is another point to which the weather has given importance. The experience of our sewaged meadows during the past season has not been so favourable in this respect as might have been expected. It appears that the Italian ryegrass, the

plant by which sewage has hitherto been chiefly utilized, requires a moist, cold atmosphere, as well as a well-fed, cool, moist soil, to ensure a luxuriant succulence of growth. The Beddington meadows, which receive the waste of Croydon, and which in May presented such a wonderful coat of grass as the result of irrigation—30 inches high and as thick as it could stand, and weighing 12 or 14 tons per acre—have not yielded by any means so well at their second and third cuts this summer, notwithstanding the flood of filthy water which at intervals has been poured over them. The tendency of the plant to form its seed spike seems irresistible in hot, dry weather, however the growth of grass may be urged by irrigation of the soil; and a first cut, of 10 to 14 tons per acre, is followed by one of 7 or 8, and that by one of 4 or 5 tons in a hot July or August. This must be taken into their calculations by those who propose to utilize the sewage of London on the low-lying lands of Kent and Essex, two of the driest counties in the island.

The drought has produced a protest from Mr. Bailey Denton, C.E.; in the form of a memorial to Sir George Grey, on the water economy of the country, and on the better uses of our rainfall. Mr. Denton proposes that agricultural proceedings with reference to that matter should be made subject to some central control. Thirty inches of rain, or thereabouts, fall annually in this island. This wets its surface, which dries again and sends back so much into the air. It finds its way, by various surface channels, runnels, brooks, rivulets, and rivers, to the sea. It sinks through its surface to various depths, taking always the path of least resistance to that downward passage which gravity imposes, until at length the passage of least resistance leads to the re-appearance of this portion of the rainfall in springs at various points below that where it sank into the ground. Now, of these two latter portions of the rainfall, various uses are made. They swell our rivers, which are thus along many miles of their course made available as carriers; they fill our mill-streams, and their weight is thus turned to account as power; they provide drink for our live-stock and our population, and they feed our plants. But the surface on which the rain-water falls is covered with plants. The cultivator of these plants is thus the first owner of this water, and he is more and more awakening to the immense value of this property, and to the greatly enhanced services which, if properly directed, it can render to him as a grower of these plants. Guided by the better knowledge of this subject which now prevails, every man, either the owner or the hirer of this surface, is dealing with the water which falls upon it for his own exclusive benefit. Either each estate by itself, or it may be even each field by itself, is so drained that the rain passes through the soil and subsoil for use, instead of over its surface to waste; and after being made useful as a feeder of the plants grown in and on the soil, it is thereafter provided with as easy and as speedy an exit as possible. The field or the estate is drained, and thereafter the water, being done with, is dismissed. Now, even as regards an estate, and still more as regards a province or a district, there is room for the use of water after it has done its duty as feeder of the plants. It is applicable as

water supply for animals; it is even available again in irrigating and so in feeding plants upon a lower level. But our outfalls are every day becoming more direct and rapid in their action. Rain which used to drag sluggishly downwards through meandering streams, runs straight out to the sea. Floods, rather the result of this arterial drainage than of parallel subsoil drains, follow excessive rainfalls more immediately than they used to do. And unexpected as it may be, the influence of agricultural drainage becomes apparent on our springs, our mill-streams, and our rivers. Mr. Bailey Denton therefore urges on the Home Secretary that inquiry should be made into this subject before this piecemeal drainage of the land shall have injured what he considers the imperial and general interests of the country, in an annual water supply. It is urged that the perennial water supply is, under existing management, gradually diminishing; that it is, moreover, becoming irregular—floods and droughts more rapidly alternating; that properly conducted, on the other hand, under-drainage is capable of securing greater regularity and abundance of the water supply—certain districts subject to seasonal drought being capable of supply by the storage of the water discharged from drained land during winter and spring. And there are other considerations urged why an inquiry should at once be directed by the Government into the effect of under-drainage on our river systems, and generally into the larger question of the water economy of the country.

We see that the 'Agricultural Gazette' calls attention to that curious illustration of the natural compensating powers of our climate in the case of drought, which it believes the dew-ponds of our chalk downs to present. We do not know if exact inquiry has been made by any scientific man into the phenomena of the Berkshire dew-pond, but the subject seems well worth investigation. Perched on the very summit of a chalk down, made an impervious cup, and filled artificially in the first instance, it seems to supply so large a quantity of water daily to the flock frequenting it, and is at the same time so exposed to loss by evaporation, that a great increment by a deposit of dew upon its surface (possible enough in cases where a moist southerly wind, for example, may be slowly passing over a hill top during a clear night, when the cooling process by radiation is excessive) seems the only possible explanation of the rarity of its entire exhaustion during the summer months. That, at all events, is the popular explanation of the phenomenon, and it is quoted by the 'Agricultural Gazette' as an illustration of the compensating powers which, in a dry season, our climate must everywhere possess.

Whatever the difficulties or injury inflicted by a prolonged summer drought, it does not appear that they at all weaken or diminish those evidences of agricultural energy and prosperity which the exhibitions of our great agricultural societies have evinced. The annual meetings of the English, Scottish, and Irish National Agricultural Societies have been unusually illustrative of our rapid progress in the field. In particular, at the Newcastle meeting of the English Society, the efforts of implement manufacturers and of stock farmers were well illustrated. "Agriculture," as one reporter has it, "may be said to begin

with the tillage of the soil, and end with the manufacture of meat; and Mr. Fowler's steam-plough standing at one end of the manufacture, and Mr. Cruickshank's short-horn bull 'Forth' standing at the other end, may be thus considered to include between them its whole scope, extent, and range. Every line upon the scale which separates these extremes has been well represented at this meeting, but the best and most numerous illustrations of the whole are those of tillage implements on the one hand, and short-horn stock upon the other. Never before has so good a collection or so thorough an examination of tillage implements been made, and never before have better classes of short-horn cattle been exhibited."

The principal novelty on the ground here was Mr. Fowler's new plan of applying steam-power to the cultivation of the land, to which the judges awarded the Society's head prize. He succeeds here in making two of the ordinary small threshing-engines which are everywhere employed throughout the country, stationed one at each end of the furrow where the steam-drawn plough is working, to combine their force upon it. The engine which the plough is leaving is pulling it as well as the engine which it is approaching. The wire rope is laid around the horizontal clip-drums underneath each engine, and its ends are fastened in the usual way upon the gearing of the plough in front of it and behind it on drums there, which, gearing into one another, are so arranged that any pull upon the plough by the rope in front resolves itself to some extent into a tightening of the rope behind it. This ensures that the rope is always taut around both the engine-drums; and the consequence is, that when both engines are at work, they are each pulling at the rope, and each is contributing its force to the line by which the plough or cultivator is being drawn. Very good work was made at Newcastle by Fowler's apparatus thus employed, and this plan is evidently a step in advance upon the double-engine system which Fowler as well as Savory has hitherto adopted. Where two engines are employed, and only one is in use at a time, each must be of double power, and the waste by radiation is constant in the case of each, notwithstanding that each is only half its time at work. The fuel consumed must therefore, in such a case, be excessive. And there is this further advantage in the double-engine system when the two engines co-operate, that neighbours may combine their engines for work of any special difficulty, the engines being severally at the same time of just the right power both for threshing purposes and for ordinary light-land cultivation.

We may mention, among the events of the past summer, the publication of extremely suggestive lectures on Dairy Farming, which had been previously delivered before the Royal Agricultural College, by Mr. Harrison, C.E., of Frocester Court, Gloucestershire. In addition to the mere detail of good practice which these lectures describe, they enumerate a great many facts and develope very many ideas and suggestions well calculated to excite the attention and the thought of those to whom they were addressed. Among these we may mention that the author points out that the dairy districts are, for the most part, confined to those geological formations which were deposited during the existence

of vertebrate animals upon the earth. Phosphates applied to the soil bring about the growth of clovers among the grasses, and they are also especially necessary on dairy farms, as evidenced by the quantity of them which exists in the milk or cheese sold off such farms; and it is a curious circumstance that the cheese-dairying especially should be confined to those geological districts where the formation contains not the mere stony remains of shell-fish and crustaceans, but the *bone-dust* of a higher order of animals. Among the other facts specified in these lectures is the existence and the uses of enormous quantities of earth-worms in the soil of grass lands. An experiment over a considerable surface of land led to the estimate of their quantity at 1,000 lbs. weight per acre; and it is declared that so large a quantity must, by its effect on the texture of the land, and by its ultimate addition to the very substance of the land, be an important contribution to its fertility.

Some discussion has arisen in connection with dairy-farming in Cheshire, from a paradoxical speech by Sir H. Mainwaring, Bart., at a recent agricultural meeting, when he set himself to arouse thought and excite controversy amongst the dairy-farmers of that county by the confident utterance of what appeared to them, as it does to us, in direct opposition to both local and general agricultural experience. His assertions were that drainage, bone-dust, and broad-breasted bulls had been the ruin of the Cheshire dairy-farmers. But the facts unquestionably are that the drainage of the pasture-lands of Cheshire, the application of bone-dust to them, and the short-horn cross upon their dairy-cows, have been of the greatest agricultural service in that county! Sir H. Mainwaring's idea that over-drainage injures grass is, however, to some extent, countenanced by the first or second year's experience of it; the wet-land grasses disappear before the better grasses suitable to the improved condition of the soil make their appearance; but the ultimate influence of drainage upon grass-lands is rarely unsatisfactory. The use of bone-dust, again, tends in a very remarkable degree to the improvement of the pastures by the extraordinary development of the clover-plant, which immediately follows. And there cannot be a doubt that the Welsh or long-horned cattle, formerly common on the Cheshire farms, have been greatly improved and, in some instances, usefully displaced by the short-horn breed, which stands at the very head of the cheese-producing breeds of the country.

We have only one more fact to add to our quarterly summary of agricultural intelligence. The Royal Agricultural Society of England has offered 50*l.* for a prize on middle-class education, having especial reference to those who are dependent on the cultivation of the soil. They were informed by Mr. Morton, at the general meeting held last December, that although by their charter they had been incorporated for the very purpose of promoting the education of the farmer, yet that particular object specified in their charter had hitherto received from them no attention whatever. A committee was thereafter appointed to consider in what way the "seventh national object" specified by the charter could be promoted, and this is the result of the committee's inquiries. It seems to us that the offer of a prize on middle-class

education is entirely abandoning the subject to which they are committed by their charter; and that they will properly discharge the duties which it imposes on them only by promoting the professional education of the agriculturist—this being done by giving encouragement and guidance to the existing means of agricultural education.

II. ASTRONOMY.

(*Including the Proceedings of the Royal Astronomical Society.*)

We have but few important advances to chronicle in general astronomy, although a glance at the proceedings of the Astronomical Society for the last few months will show that slow but sure progress has been made by English observers. We may commence by reminding our readers that a prize of 200 ducats (about 90*l.*) has been offered by the Academy of Sciences at Vienna for the best research on the movements of the fixed stars. The last day for sending in the papers is fixed for December 31, 1865. We cannot help thinking that the time here allowed is far too short. The base line used by astronomers in investigating the movements of these distant bodies being the diameter of the earth's orbit round the sun, it will take six months to accumulate merely one set of observations, and as the minuteness of the observed movements renders it highly desirable to verify the first obtained data by numerous subsequent observations, it is scarcely likely that any new and striking measures of parallax can be included in the memoirs, unless, indeed, the principal observations have already been made by the competing astronomers. In such a case as this science would be more advanced by offering a larger sum as a prize, and allowing the time to extend to five or six years.

Our readers are doubtless well aware that a new Astronomical Society was founded last year at Heidelberg. This society is essentially international in its character, and numbers amongst its members not only German, but also English, French, Italian, and Russian astronomers. Several of its most eminent members are dividing the work between them; some are investigating the disturbances which have taken place in the movements of Mercury, Venus, Mars, Jupiter, Saturn, and Uranus, in some cases going back as far as 1770. Others have divided the asteroids amongst them, each member taking a planet under his care, and observing its motions periodically. A society of earnest workers acting in this manner is more likely to further the objects of their science than are any two of the so-called learned societies as at present constituted.

The star 40,196 (Lalande) is noted for its singular variability, and M. Goldschmidt still continues his accurate investigations on its changes. The result of his observations is, that it accomplishes its cycle in a period of 197 days. It remains nearly invisible for 61 days,

it then gradually increases in luminosity for 56 days, remains stationary for a perceptible period, then diminishes for 78 days, and finally disappears.

At the last meeting of the French Association for the advancement of astronomy and meteorology, founded by M. Leverrier, a new reflecting telescope was exhibited, having a speculum nearly a yard in diameter. It is of glass, silvered by chemical means, the process having been explained to the meeting. We understand that these reflectors, first employed by M. Foucault, are rapidly making way in this country, their cheapness, lightness, and the ease with which they can be resilvered when tarnished, rendering them formidable rivals to both refractors and reflectors of the ordinary kind.

The subject of meteorites is still being pursued by M. Heidinger, of Vienna, who has so thoroughly identified himself with the investigation of these bodies. In a letter to M. A. Quêtelet, of Brussels, he gives some interesting particulars of the fall of a supposed aërolite at Inly, near Trebizond. It fell in an easterly direction in December last with a terrific explosion, resembling the discharge of hundreds of pieces of ordnance. Some pieces supposed to have formed part of it have been forwarded to Vienna, but from the examination already made of them, their origin seems to be rather terrestrial than cosmical. Professor Kenngott, director of the Mineralogical Museum of Zurich, has lately forwarded to M. Heidinger a specimen marked native iron from Styria, but which he suspected was meteoric. The director of the Imperial Museum at Vienna had it cut and polished. Subsequent treatment with acids left no doubt of its cosmical origin. It also contains crystals which appear to be olivine and pyrosene, and its general character seems to identify it with the meteorite which fell many years back at Steinbach, in Saxony. It would be interesting if the directors of museums would submit to similar tests any specimens of so-called native iron that they may have in their possession.

The Royal Astronomical Society.

Further observations of the newly-discovered satellite of Sirius have been communicated to the Society during the last few months. M. Otto Struve has determined, from observations extending from March 16, 1863, to March 28, 1864, that its annual change of distance is equal to $+0''\cdot77$, and its annual change of position $-5°\cdot7$. He considers that on the first glance we are led to the conclusion that the hypothesis of accidental juxtaposition of the two stars is by far the most probable, a conclusion which is even strengthened by some of Mr. Bond's observations. Although a strong objection against their merely optical association must be derived from the circumstance that Herschel, at the end of the last century, when with this supposition the small star ought to have had a distance of about one minute from Sirius to the south-west, never noticed its existence, though it is well known that about that time he frequently observed Sirius as a test object for the quality of his mirrors. After giving several other arguments on each

side of the question, Professor Struve concludes that he must suspend judgment on the physical connection or merely optical juxtaposition of the small star until next year. In reference to this paper Mr. Dawes remarked that the star was visible in strong twilight, and he therefore conceived that it was not so very small in itself, but only appeared so in consequence of its proximity to the prodigiously bright star of which it was the companion.

In an elaborate and important paper on the probable error of a meridional transit-observation by the "eye and ear," and chronographic methods, read by Mr. Dunkin at one of the recent meetings of the Society, he comes to the conclusion that the chronographic observations of a transit are attended with much less probable error than an eye-and-ear observation; the personal discordances between the different observers are also comparatively small by the former method, and the general steadiness of observing by it is very remarkable. In the results for right ascension the probable error for chronographic transits is also much less. Some discussion followed the reading of this paper. The president, Dr. De la Rue, referred to an improvement upon a proposal made some time ago by Professor Wheatstone for increasing the accuracy of transit observations. This was that a system of wires should be arranged in the transit instrument, which, when the star was brought between them, should follow its movement; and when the star passed the optical axis of the instrument or any number of known points from that axis, then the chronographic signal would be made by the wires making electrical contact, so that a number of records would be obtained independent of the will of the observer. Col. Strange mentioned that the Paris astronomers had expressed themselves decidedly against the chronographic method; he did not, however, agree with this, and had therefore, with the sanction of the Government, ordered a complete chronographic apparatus for the use of the Indian survey. Col. Strange further remarked that Professor Wheatstone's suggestion of having a telescope so constructed that the star should be automatically followed over the wires had already been carried out. When at the Paris Observatory, he had examined an apparatus of this description made by M. Redier; the wire was carried so steadily across the field, so exactly with the same velocity as the passage of the star, that the intersection of that star with the wire was a matter of the most perfect ease and certainty; in fact, there was ample time for the observer to call an assistant to verify the observation before leaving the instrument. Mr. Dunkin in reply to the opinion that the chronographic system tended to produce bad eye-and-ear observers, remarked, that at the Royal Observatory, observers, who had practised the chronographic system for ten years, could still, when the apparatus was out of order, take eye-and-ear observations with as much accuracy as formerly.

The appearances of the solar surface are still attracting great attention. The Rev. W. R. Dawes speaks very decidedly as to the total absence of any objects on the photosphere which could be compared to willow-leaves in their form. He has for many years been familiar with granulations or granules of forms and sizes so various as

to defy every attempt to describe them by any one appellation. Upon more quiet and perfect view of these granulations, it appears that they are not individual and separate bodies of a peculiar nature, but only different conditions as to brightness or elevation of the larger masses forming the mottled surface. Between the granules the shaded portions are in many places pretty thickly covered with dark dots like *stippling with a soft lead pencil*, but he was struck with the extreme rarity of a long and narrow shape among the granules with which the surface of the sun is covered. They may perhaps be sometimes compressed into a longer form under the influence of the same forces which produce the longer threads or *straws* on the penumbra, but one of the most striking features is the entire absence of uniformity in the brighter portions with respect both to their size and shape. Mr. Dawes further said, that one of the most remarkable things connected with the matter, was that whereas these granules, or "rice grains," were easily seen,—a small telescope with a power of 40 or 50 bringing them into view,—Mr. Nasmyth should have accepted them as his "willow-leaves," which he says are so difficult to see with an 8-inch aperture. Mr. C. G. Talmage confirmed Mr. Dawes's statement. Since 1861, he had most carefully scrutinized the surface of the sun both at Nice, at Paris, and in England, with 4-inch, 6-inch, and 8-inch object-glasses with powers up to 500, but had never seen the slightest trace of "willow-leaves," "rice grains," or "thatch." In the discussion which followed the reading of these papers, Dr. De la Rue remarked, that it is to the sun himself and to other observers that the confirmation or non-confirmation of Mr. Nasmyth's discovery must be left; he himself maintained, notwithstanding what had fallen from other astronomers, that it was a substantial discovery.

At the end of last year the assistant-secretary of the Society, Mr. Williams, gave an abstract of the record of thirty-six eclipses in the Chinese historical work called 'Chun Tsen.' Mr. Williams had converted the Chinese dates into dates according to the Julian calendar. The Astronomer-Royal has lately compared the 'Chun Tsen' eclipses with those calculated in the French work entitled 'L'Art de Vérifier des Dates,' and he finds that, of the thirty-six eclipses, thirty-two agree with the computations of modern theory, whilst in the remaining four it is very probable that there is an error in the Chinese record.

Some very important notes on the binary star, α Centauri, are given by Mr. E. B. Powell. He invites attention to the important portion of the orbit now about to be described, *viz.* the part in the immediate neighbourhood of the lesser maximum of distance. If this maximum be accurately determined, one most prominent feature in the path will be fixed; and then, as the companion will revolve with continually increasing rapidity till its distance from the primary diminishes to 1″ or less, a really excellent orbit will be calculable in 1870 or thereabouts. Now that so much discussion is going on respecting the changes which are supposed to have taken place in nebulæ, it may be of interest to record that Mr. Powell considers that decided changes have taken place in the nebula about η Argus. In 1860, the whole nebula had faded away very considerably, and it had altered its form,

the nebulous matter having receded so as to leave open the southern end of the lemniscate vacuity. Mr. Abbot first published the fact that η is no longer in the dense portion of the nebula where it was seen by Sir John Herschel.

In 1857 the Astronomer-Royal made a communication to the Astronomical Society on the means available for correcting the received measure of the sun's distance from the earth. Among the different subjects of observation applicable within some years to this object, he particularly indicated the transit of Venus, December 6, 1882, treated by the method of comparison of duration of transits at different places, as one meriting most careful consideration. The Society has lately been favoured by the learned professor with a further communication on this transit, illustrated with orthographic projections of the illuminated sides of the earth for ingress and egress. From these it is seen that on the seaboard of the United States of America, the duration of transit would be shortest. The possible maximum of shortening being 2·00, that at the United States is represented by 1·78. The Southern States, as far as the Gulf of Mexico, would be almost as favourable, and would have the advantage of a higher sun at egress. Bermuda would be also a very good place, the whole shortening there being 1·8. The circumstances therefore are exceedingly favourable for the selection of observing stations at which the duration of transit will be much shortened. The choice of stations where the duration of transit will be longest is more limited, and the practical difficulties rather greater. The most favourable position that can be found is between Sabrina Land and Repulse Bay, where the lengthening of the transit would be represented by 1·61—a very large amount; the geometrical possible maximum being 2·00. This point near Sabrina Land being the only one very suitable for the observation, the Astronomer-Royal thinks it very desirable that a reconnaissance should be made of different points on the Antarctic continent, and that it should not be long deferred. The first locality to be examined is that in 7^h E. longitude between Sabrina Land and Repulse Bay, the points to be ascertained being 1st, whether the coast is accessible on the 6th of December; 2nd, whether a latitude of 65° can be reached; and 3rd, whether the sun can usually be seen well on December 6th at 2^h and 8^h Greenwich mean solar time. Should the answer to the first or third of these questions be negative, then it would be proper to examine other portions of the south continent, say in longitude not very different from 5^h west, but with no particular restrictions except that of gaining the highest possible south latitude. And the only point for inquiry would be, how well the sun can usually be seen on December 6th at the hours above named.

Referring to an adverse criticism which Messrs. Stone and Carpenter made upon Professor Bond's drawing of the nebula of Orion, in which these gentlemen considered it was not so accurate as that of Sir John Herschel, Professor Bond has communicated to the Astronomical Society a detailed defence of his own drawing, and a notice of that of Sir J. Herschel. He appears to show very satisfactorily that Messrs. Stone and Carpenter have not been altogether warranted in their

unfavourable notice, as micrometric measurements prove that, in several instances, Herschel's drawing is less accurate than Bond's. It would be more satisfactory if some independent observer were to examine the matter minutely, for it is really important, in view of the questions which have been raised respecting the reality of changes in the aspect of the nebula. The reading of these remarks gave rise to a short discussion, in which Mr. Stone, Dr. Winnecke, and the Rev. C. Pritchard took part. It was generally agreed that, from the acknowledged ability of Mr. Bond, his drawing will probably become the standard of reference for the present epoch ; but it was most important that attention should be directed to all suspected deviations of that drawing from accuracy, in order that they might now be settled while there is an opportunity of doing so.

Some very beautiful photographs of the sun, taken by the Ely Helioautograph, were exhibited at the same meeting by Professor Selwyn. Some of them were $6\frac{5}{8}$ inches in diameter, and contained spots and faculæ very clearly marked. He considered that his photographs did not support a result obtained by Mr. Stewart, who, from an examination of the sun pictures taken at Kew, considered that it was a nearly universal law that the faculæ belonging to a spot appear to the left of that spot. Professor Selwyn believes that the faculæ surround the spots in the same way as the edges of a crater surround the cavity of a crater, not favouring one side or the other, but lying fairly round them. A continuous series of solar photographs cannot fail to give the means of proving or disproving such statements.

We have already mentioned the series of Chinese eclipses communicated to the Society by Mr. John Williams. This gentleman, a profound Chinese and Japanese scholar, has more recently communicated another series, from B.C. 481 to the Christian era, which he has extracted from a Chinese historical work entitled 'Tung Keen Kang Muh,' in 101 volumes, first published during the Myng dynasty, about 1473. The dates have been carefully verified by a comparison with a set of chronological tables published in Japan, which supply not only the Chinese cycles and their years, arranged according to their *Kea Tsze* system, but also the years in the European system, answering to their cyclical years. The work of exhuming these records of eclipses must be very laborious, and Mr. Williams deserves great praise for the service which his linguistic talents enable him to render to astronomical science.

Respecting the bright band bordering the moon's limb in photographs of eclipses, Professor Airey described some experiments which he says leave no doubt on his mind that the phenomenon in question is a mere nervous irritation of the retina, produced by the view of the conterminous black and white portions of the photograph.

An elaborate mathematical paper on shooting-stars in March, by A. S. Herschel, Esq., cannot be given in abstract.

R. Hodgson, Esq., has communicated to the Society a note on the achromatic object-glass, illustrated with several diagrams, in which he shows how wide and large have been the variations made by foreign opticians, whilst the form adopted by English opticians is the same as

that used by the inventor, John Dolland, in 1758. A form adopted by Steinheil in 1860, computed from a paper by Gauss published in 1817, is spoken of very highly as admitting of an increased aperture for a given focal length. With reference to the discovery of achromatism, it is an interesting fact that in a curious old folio volume, entitled 'Zahn's Optics,' printed at Nuremberg in 1702, amongst other diagrams one is given of a pair of lenses exactly similar to an achromatic object-glass of the form adopted by Dolland. Mr. Hodgson speaks in high terms of the regularity and great excellence of the optical glass now made by Messrs. Chance, of Birmingham.

The Rev. W. R. Dawes has announced the curious fact, that the small star *s. p. μ Herculis*, which in the year 1856 was discovered by Mr. Alvan Clark to be close double, is a *binary* system, the variation in position amounting to about 18° within the last five or six years.

Mr. Pogson now considers that the identity of his last new planet with *Freia* is quite established, and the name *Sappho* is again at liberty for future use. He has now provided another candidate for the name, this time most certainly and evidently a new planet. Its magnitude is 10·4.

Mr. De la Rue reports most favourably of the performance of a telescope of new construction, sent by Dr. Steinheil for exhibition at his reception held at Willis's Rooms on June 11. The objective has an aperture of about 4·2 inches, and a focal length of about 40 inches. Dr. Steinheil is now engaged upon an object-glass composed of three lenses of 6 inches aperture, and only 30 inches focal length.

III. BOTANY AND VEGETABLE PHYSIOLOGY.

Dr. Asa Gray makes the following remarks in regard to *Calluna vulgaris* as an American plant:—

The earliest published announcement that we have been able to find of *Calluna vulgaris* as an American plant is that by Sir William Hooker, in the Index to his 'Flora Boreali-Americana' (ii. p. 280), issued in 1840. Here it is stated that—"This should have been inserted at p. 39, as an inhabitant of Newfoundland, on the authority of De la Pylaie." Accordingly in the seventh volume of De Candolle's 'Prodromus,' to the European habitat is added "*Etiam* in Islandia et in Terra Nova Americæ Borealis." But it does not appear that Mr. Bentham had ever seen an American specimen. He also overlooked the fact (to which Dr. Seemann has recently called attention) that Gisecke, in Brewster's 'Encyclopædia,' records it as a native of Greenland. No mention of it is made by Dr. Lang, in his enumeration of the known plants of Greenland, appended to Rink's 'Geographical and Statistical Account of Greenland,' published in 1857; from which we may infer that the plant is perhaps as rare and local in Greenland as in Newfoundland, or even in Massachusetts. In September, 1861, Dr. Gray announced the unexpected discovery, by Mr. Jackson Dawson,

of a patch of Heath in Tewksbury, Massachusetts; adding the remark, that "it may have been introduced, unlikely as it seems; or we may have to rank this Heath with *Scolopendrium officinarum*, *Subularia aquatica*, and *Marsilea quadrifolia*, as species of the Old World so sparingly represented in the New, that they are known only at single stations—perhaps late-lingerers rather than new-comers." And when, in a subsequent volume of the 'American Journal of Science and Arts,' Mr. Rand, after exploring the locality, gave a detailed account of the case, and of the probabilities that the plant might be truly native, we added a note to say that the probability very much depended upon the confirmation of the Newfoundland habitat. As to that we had been verbally informed, in January, 1839, by the late David Don, that he possessed specimens of *Calluna* collected in Newfoundland by an explorer of that island. Our friend, Mr. C. J. Sprague, however, after having in vain endeavoured to find in any publication of Pylaie's any mention of this Heath in Newfoundland, and having ascertained that no specimen was extant in Pylaie's herbarium, or elsewhere that he could trace, naturally took a sceptical view, and in the 'Proceedings of the Boston Natural History Society' for February and for May, 1862, he argued plausibly, from negative evidence, against the idea that any native Heath had ever been found in Newfoundland or on the American continent. It is with much interest, therefore, that we read the following announcement by Dr. Hewett C. Watson: "Specimens of *Calluna vulgaris* from Newfoundland have very recently come into my hands, under circumstances which seem to warrant its reception henceforth as a true native of that island. At the late sale of the Linnean Society's collections in London, in November, 1863, I bought a parcel of specimens, which was endorsed outside, 'A Collection of Dried Plants from Newfoundland, collected by — McCormack, Esq., and presented to Mr. David Don.' The specimens were old, and greatly damaged by insects. Apparently they had been left in the rough, as originally received from the collector; being in mingled layers between a scanty supply of paper, and almost all of them unlabelled. Among these specimens were two flowerless branches of the true *Calluna vulgaris*, about six inches long, quite identical with the common Heath of our British moors. Fortunately, a label did accompany these two specimens, which runs thus: 'Head of St. Mary's Bay.—Trepassey Bay, also very abundant.—S.E. of Newfoundland, considerable tracks of it.' The name '*Erica vulgaris*' has been added on the label in a different handwriting. All the other species in the parcel (or nearly all) have been recorded from Newfoundland, so that there appeared no cause for doubt respecting the *Calluna* itself. And, moreover, the collector had seemingly some idea that an especial interest would attach to the *Calluna*, since in this instance he gave its special locality, and also added two other localities on the label. But there is very likely some mistake in the name of the donor to Mr. Don. It is believed by Sir William Hooker that he was the same Mr. W. E. Cormack whose name is frequently cited for Newfoundland plants in the 'Flora Boreali-Americana.' This gentleman was a merchant in Newfoundland, to which he made several

voyages. We should recollect that the *Calluna* advances to the extreme western limits (or out-liers) of Europe, in Iceland, Ireland, and the Azores. The step thence to Newfoundland and Massachusetts, though wide, is not an incredible one."

Without doubt these are the very specimens referred to by Mr. Don, then curator of the Linnean Society; and now that the stations where they were collected are made known, we may expect that the plant will soon be rediscovered, and its indigenous character ascertained.

M. Cahours finds that fruits, such as apples, oranges, and lemons, after being pulled, absorb a portion of oxygen from the air, and give out carbonic acid. The quantity of the CO_2 given off is greatest in darkness and at a high temperature. Similar phenomena take place when the fruits are placed in oxygen gas. When the fruits begin to decay, then a large quantity of CO_2 is formed, so that the atmosphere around the fruits becomes loaded with it and very unwholesome. This occurrence depends on a chemical change in the juices of the fruits. Carbonic acid is given off by decaying fruits when placed in azote, proving that it is not produced by absorption of the oxygen of the air. The change in medlars, called by Lindley "bletting," is similar, and is accompanied with fermentation, causing sugar to be converted into alcohol, carbonic acid, and an ether which gives the peculiar aroma to the fruit.

Dr. Seemann has made a list of 279 species in which double flowers occur. Of these, 234 are exogens and 45 endogens. Of the exogenous species, 166 are polypetalous, 66 gamopetalous, and 2 apetalous. The vast majority of plants producing double flowers occur in the Northern hemisphere. Not a single species with double flowers has been noticed in Polynesia and Australasia. A few occur in South Africa and South America.

Mr. Carey Lea, of Philadelphia, finds that ozone checks the growth of the roots of plants, and that it prevents the formation of mould. The ozone which he used was generated by the action of sulphuric acid upon chameleon mineral.

It has been found that vegetable ivory in contact with concentrated sulphuric acid assumes a fine red colour, almost equal to magenta. At first it is pink, but gradually becomes deeper until it attains a purple when the acid has been allowed to act for twelve hours.

Professor Braun, in the 'Proceedings of the Berlin Academy,' gives a list of 37 species of Marsilea. Of these, 4 are found in Europe, Northern Africa, and Asia; 6 in Southern Asia; 12 in Central and Southern Africa and the islands adjacent; 9 in North and South America—one of which is common to both North America and Europe; 5 in Australia; and 4 in the South Sea Islands—only 2 of which, however, are peculiar to them.

Neotinea intacta of Reichenbach, an orchid allied to *Aceras* and not unlike *Habenaria albida*, has been recently added to the Irish

Flora. It was found in the woods of Castle Taylor, in Galway, by Miss More. It has been previously known as a native of Greece, Malta, Algiers, south of Germany, and Portugal.

Goodyera repens, the northern limit of which has been recorded as Perth and Forfar, has been found recently in large quantity by Mr. Claudio L. Serra in fir woods at Dalmeny Park, near Edinburgh. *Corallorhiza innata* has likewise been found in woods near Alloa by Dr. A. Dickson, and at Denholm Green, near Cavers. *Draba rupestris* and *Sagina nivalis* have been found by Professor Balfour on Stobinnain, a mountain upwards of 3,800 feet above the level of the sea, at the head of Balquidder and close to Ben More.

In the north-western provinces of India, the following plants are used for poisoning food with the view of robbery, according to Dr. James Irving:—*Datura fastuosa* and *alba*, *Aconitum ferox*, *Cannabis indica*, *Nerium Oleander*.

Mr. Edward Tuckermann has published observations on North American and other Lichens. The Lichens are chiefly those collected by Mr. Wright in the Island of Cuba. These specimens afford a view of a tropical Lichen flora as extensive and elegant as has perhaps ever been given.

M. J. Duval-Jouve has published an account of the Natural History of the Equisetums of France, illustrated by 10 plates. In reporting upon it, Messrs. Decaisne, Tulasne, and Brongniart make the following remarks:—The genus Equisetum constitutes by itself one of the most remarkable families of Vascular Cryptogams. The peculiar external forms of these plants, the nature and disposition of their organs of vegetation, and the characters of their reproductive organs, isolate them apparently from the families near which they are placed, on account of resemblances in certain essential points of character. These plants have been long special objects of study, and of late years important discoveries have been made in regard to their mode of reproduction. The researches of Thuret, Hofmeister, and Milde, from 1848 to 1852, have shown the similarity existing between Equiseta and Ferns in their mode of fecundation. M. Duval-Jouve has extended their observations, and has issued a very complete work on the family. He has followed the development of the various species of Equisetum from the state of spore up to the fully-formed fructification. He describes the structure of the stems, the branches, and the adult roots in the different species, and points out the relations which exist among the various tissues of which they are composed. He also follows the mode of development of the tissues; the formation and multiplication of the cells, which, at the summit of the bud, determine the first evolutions of the stem; the first appearance of the sheaths, which in these plants take the place of the leaves; and the formation of the stomata and the vessels. The sheaths, which at intervals surround the stems and branches in the plants, have generally been looked upon as verticils of imperfect leaves; but M. Duval-Jouve shows that they are first formed as a continuous ring, the free

border of which at a later period forms the teeth of the sheaths, and that, on this account, their resemblance to the foliar organs is rendered doubtful. The siliceous covering is considered as a secretion of the part of the epidermal cells which is in contact with the air. It is an inorganic secretion outside the cells, and resembling in some respects the waxy matter deposited on the surface of the leaves and fruits. Full details are given of the structure of the stomata; their position being limited to the parts of the epidermis which cover a parenchyma filled with chlorophyll. The vascular system of Equisetums consists of a cylinder of distinct and very regular bundles of annular or spiral vessels. Regular lacunæ also occur in the inside of these bundles, formed by the absorption of the more internal of the vessels. The development of spores resembles that of the pollen-grains, and the spiral filaments surrounding the spores are formed from the outer membrane of the spore itself. These spores when germinating produce, as in ferns, a small green irregularly-lobed frond or prothallus, called by M. Duval-Jouve *Sporophyme*. On the prothallus are produced Antheridia filled with spermatozoids or antherozoids, and Archegonia containing each a germ-cell or embryonary-cell, destined after fecundation to produce the fructiferous frond. The prothalli are usually unisexual. The expulsion of the antherozoids and their application to the Archegonia are favoured by humidity. The following species are described:—1. *Equisetum maximum*, Lam. 2. *E. sylvaticum*, L. 3. *E. pratense*, Ehrh. 4. *E. arvense*, L. 5. *E. littorale*, Kuhl. 6. *E. limosum*, L. 7. *E. palustre*, L. 8. *E. ramosissimum*, Desf. 9. *E. variegatum*, Schl. 10. *E. trachyodon*, Al. Bra. 11. *E. hyemale*, L.

IV. CHEMISTRY.

(*Including the Proceedings of the Chemical Society.*)

The short space we can devote to the Chronicles of Science in this number, obliges us to condense into the smallest bulk the little we have to record of the progress of Chemistry.

Following our ordinary arrangement we may first draw attention to some experiments with oxygen, which, although made some time ago, have but recently become known to English chemists. Dr. Meissner,* of Göttingen, has devoted himself to a thorough investigation of the ozone and antozone question; and in the course of his experiments has obtained some curious results. The most singular, perhaps, is the discovery that *antozone* possesses a remarkable attraction for water, which it takes up in the shape of vapour forming a mist or cloud. This the author supposes to explain many meteorological phenomena. In the course of the experiments he also satisfied himself that ozone and antozone are produced from ordinary oxygen in

* 'Untersuchungen über den Sauerstoff.' Hanover, 1863.

equivalent proportions, and that one cannot be formed without the other, thus satisfactorily demonstrating the triple nature of oxygen. Meissner's results and opinions, however, do not pass unchallenged, and Von Babo* throws great doubt on the existence of the so-called antozone.

Some experiments by Weyl † on the combinations of ammonium deserve a passing notice. By placing potassium in contact with ammonia in a closed tube the author obtained an unstable compound in which he supposes one of the hydrogen atoms of the ammonia to be replaced by potassium. He proposes to ascertain if it be possible to obtain oxides and salts of this compound, and in this way to arrive at some conclusion respecting the metallic nature of ammonium.

Tungsten, a metal which presents some anomalous characteristics, has been made the subject of some investigations by the MM. Persoz.‡ They have not yet published their results in detail, and now only announce the discovery in the metal of several distinct radicals which give rise to various oxygen compounds, acids, and bases.

The colouring matter of the emerald has been a subject of discussion. By some the colour was supposed to be due to organic matter only; but Wöhler and Rose § have recently determined the presence of a very minute proportion of oxide of chromium to which they attribute the colour, admitting the possibility of some organic matter being present. A stone, however, which they kept for an hour at the temperature of melted copper showed no sign of alteration.

It may be worth mentioning that M. Aupin has determined the presence of silver in the water of the Dead Sea, a ton of the saline residue of which contains seven grains of the precious metal.

In organic chemistry we may announce the discovery of yet another hydrocarbon in that highly complex mixture, coal tar.‖ The discovery seems to have been made about the same time by MM. Bechamp and Naquet. The new body boils at about 140° C., and M. Naquet announces its composition to be $C_9 H_{12}$. Beilstein, however, asserts it to be identical with *Xylene* $C_8 H_{10}$.

Some recent cases of poisoning have caused a considerable extension of our knowledge of vegetable poisons. Digitaline has been made the subject of investigation by several French chemists, and especially by MM. Grandeau ¶ and Lefort.** The experiments of the former were principally directed towards obtaining a ready and decisive means of detecting the poison in organic mixtures, in which he has to some extent succeeded. He has found that digitaline passes with tolerable facility through a dialyser, and may be extracted from the evaporated diffusate by means of alcohol. The most characteristic reaction he has found to be that produced when digitaline is moistened

* 'Annal. der Chem. und Pharmacie,' Dec. 1863, p. 265.
† 'Poggendorff's Annalen,' No. iv., 1864, p. 601.
‡ 'Comptes Rendus,' June 27, 1864.
§ Ibid.
‖ 'Comptes Rendus,' July 6, 25, and Aug. 4.
¶ 'Comptes Rendus,' vol. lviii. p. 1048.
** 'Chemical News,' vol. x. p. 99.

with sulphuric acid and exposed to the vapour of bromine. It then instantaneously assumes an intense violet colour, varying in shade according to the amount of the substance present, but sufficiently distinct with 0·0005 of a gramme. M. Lefort's investigation was confined to the different properties of the various digitalines found in commerce; and we may say in a few words that the differences remarked were so great as to show that digitaline at the best is an extremely variable substance, the use of which as a medicine should at once be prohibited.

A lamentable occurrence at Liverpool has been the occasion of some experiments on the chemical properties of the Calabar bean by Dr. Edwards,* which will be found of great interest to toxicologists.

While on the subject of the detection of vegetable poisons we must mention that Dr. Helwig † has found that by a very carefully regulated temperature morphia, brucia, strychnia, veratria, aconitia, and atropia may be sublimed, and the microscopic appearance of the sublimate become the means of identification.

Cahours, whose experiments on the respiration of leaves and fruits we noticed in our last, has proceeded with an examination of the respiration of flowers.‡ The green parts of plants, it will be remembered, under the influence of light assimilate carbon and give off oxygen; the coloured parts, on the contrary, absorb oxygen and evolve carbonic acid.

In analytical chemistry we have but little to report. Professor Williamson and Dr. Russell detailed to the Chemical Society a new method of gas analysis, no description of which would be intelligible unless accompanied by a drawing of the apparatus employed. We must therefore refer the reader to the 'Journal of the Chemical Society' for the description.

M. Schlœsing has quite recently § published a method of estimating phosphoric acid in earthy phosphates by reducing the acid in a current of carbonic oxide, and subsequently passing the volatilized phosphorus into a solution of nitrate of silver. The phosphide of silver which is formed is then converted into phosphate and weighed. This process is not likely to meet with general adoption. The determination of phosphoric acid is, however, a very important matter, especially to the agricultural chemist, and we therefore call attention to a valuable paper on the analysis of mineral phosphates by Mr. R. Warrington, jun.,‖ which contains a detailed description of the best methods hitherto pursued.

In the technical applications of chemistry one or two important discoveries have been made. The first we may notice is that of M. Pelouze,¶ who has found that the alkaline polysulphides saponify fats as easily as caustic alkalies. This discovery may considerably

* 'Chemical News,' vol. x. p. 108.
† 'Zeitschrift für Analytische Chemie,' H. 1, 1864.
‡ 'Comptes Rendus,' June 27, 1864.
§ 'Comptes Rendus,' Aug. 22, 1864.
‖ 'Chemical News,' vol. x. p. 1.
¶ 'Comptes Rendus,' July 6, 1864.

lessen the cost of producing soaps, if some effectual means of removing the sulphur compounds should be devised.

Another discovery bearing on the same subject has been made by M. Mege-Mouries,* who notices that fats in the globular state, which is induced by agitating a melted fat with warm water containing a little yolk of eggs or even soap, are saponified by a much smaller amount of alkali and in a much shorter space of time than when in the ordinary liquid state.

The colouring matters of madder have been the subjects of some investigations by M. E. Kopp,† who has found that yellow alizarine may be separated from the common commercial green substance by agitating the latter with mineral oil, in which the yellow is soluble but not the green. Caustic soda in weak solution will now separate the madder colour from the oil, and the addition of sulphuric acid to saturate the alkali now precipitates pure yellow alizarine.

These are a few of the more generally interesting subjects which have engaged the attention of chemists within the last three months.

Proceedings of the Chemical Society.

The papers which have been read at the Chemical Society since our last publication include that by Professor Williamson and Dr. Russell, On a New Method of Gas Analysis; Professor Wanklyn, On Isomeric Hydrocarbons; Professor Williamson, On the Classification of the Elements according to their Atomic Weights; Professor Stokes, On the Detection and Discrimination of Organic Bodies by means of their Optical Properties; Mr. Schorlemmer, On the Identity of Methyl and Hydride of Ethyl; Mr. R. Dale, On the Action of Baryta on Suberic Acid; and A Description of Vacuum Experiments by Dr. H. Sprengel. The session was concluded by the reading of a discourse On the Philosophy of British Agriculture, written by Professor Way.

V. GEOLOGY AND PALÆONTOLOGY.

(*Including the Progress of the Geological Survey of the United Kingdom.*)

The most important event of the past quarter affecting Geology, is doubtless the appearance of the new 'Geological Magazine,' with which is incorporated its predecessor, 'The Geologist.' The last-named periodical, though well supported when it began, had latterly become of a very inferior character, so much so that we have not had occasion to notice it in these Chronicles, and therefore its replacement

* 'Comptes Rendus,' vol. lviii. p. 864.
† 'Comptes Rendus,' Aug. 17, 1864.

by a new and ably-conducted journal is at once a welcome change to the geologist, and an important advance in the science.

The first number of the new journal opens with a brief review of "The Past and Present Aspects of Geology," which contains more "ideal" philosophy than is usually exhibited in the writings of geologists, and sets before the reader, clearly and concisely, a statement of the different phases or "aspects" of the science at the several periods in its history, pointing out and contrasting at the same time "the ideas that during each of those epochs guided the course of geological investigations, forming for the time, so to speak, the rudder of geological thought."

The original articles are all valuable contributions to geological literature. Mr. Salter's paper on "The Pebble-bed at Budleigh Salterton" is an appendix to his description of the fossils from that deposit, which was published in the last number of the 'Quarterly Journal of the Geological Society;' the author comes to the conclusion that these fossils, found in a pebble-bed of the new red sandstone period, belong to the Norman lower Silurian fauna, and are perfectly distinct from English fossils of that age; they therefore indicate the existence of a land barrier between the seas of England and Normandy during the lower Silurian period, a conclusion at which Mr. Godwin-Austen arrived, on independent grounds, some years ago. Mr. Davidson's paper on "Thecidium" is a very exhaustive examination into the value of the recent and tertiary species of the genus, and a description of their anatomy; in the course of which the author shows that many of the so-called species are mere varieties of the recent *Thecidium Mediterraneum*.

The second number quite keeps up the character of the new magazine, and contains two important papers—one by Mr. S. P. Woodward and the other by Mr. Day—besides several others of less general interest. In Mr. S. P. Woodward's paper on "The Bridlington Crag," there is a very complete and useful list of all the species of shells hitherto found in that deposit; and the comparison of this fauna with those of other accumulations, hitherto supposed to be synchronous with it, has led the author to the somewhat unexpected result that the Bridlington deposit can no longer be considered the exact equivalent of the Norwich Crag in age or in climatal conditions, and that the shells "are almost equally distinct from those of the last pre-glacial and those of the first post-glacial deposits, and is (*sic*) much more Arctic than either, as if formed during the climax of the last great age of cold in Britain." Mr. Day's paper on "*Acrodus Anningiæ*, Agass.," treats of the structure of a very remarkable shark, as exemplified by a complete lower jaw found by the author in the lias of Lyme Regis, which apparently contains teeth hitherto referred to two different genera, until now regarded by many eminent palæontologists as belonging to distinct families. Geologists have more frequently to deal with fragments than with perfect specimens, and they therefore often find, as in this case, that structures considered by them, through imperfect knowledge, to be characteristic of distinct genera, or even families, belong in reality to the same individual. Thus the philoso-

phical palæontologist becomes impressed with the consciousness of the imperfection of the geological record; while the man of mere fact—the Gradgrind and Bounderby of palæontology—still clings to his own feeble interpretation of imperfect specimens, and mistaking fancy for fact, adopts as finally true those erroneous notions which the "dreamer" only tolerates provisionally as a plausible hypothesis.

The other articles in these numbers are also interesting; besides which there are several abstracts of foreign memoirs, reviews of recent publications, reports of proceedings of field-clubs, and other matter of interest to the geologist.*

Professor von Ettingshausen has lately published a pamphlet, entitled 'Ueber die Entdeckung des Neuholländischen Charakters der Eocenflora Europa's, und über die Anwendung des Naturselbstdruckes zur Förderung der Botanik und Palæontologie,' and although its immediate object is merely to show that the author was the first to point out the Australian character of the Eocene flora of Europe, and that nature-printing can be used advantageously for the illustration and comparison of recent and fossil plants, yet it advances our knowledge of the subjects treated, by bringing prominently forward the facts essential to his argument; and we freely admit that, after reading his pamphlet, few besides his antagonist, Professor Unger, would be likely to dispute with him either of the points at issue. The advantages attending the employment of the process of nature-printing for purposes of comparison appear so obvious, that Professor Unger's opinion to the contrary is not a little remarkable; and as regards the Australian character of the Eocene plants, Professor Unger's "Dissolving Views" have long made familiar to us his opinion respecting their "insular" character, as distinguished from the inference of Professor von Ettingshausen that they belonged to a "Continental" and New Holland flora.

Dr. Dawson's memoir on 'Air-breathers of the Coal-period,' contains descriptions of all the remains of supposed air-breathers that have been found in the carboniferous strata of Nova Scotia; many of them have been described before by Professor Owen, the author, and others, so that this publication may be considered a synopsis and *résumé* of the whole subject. The vertebrate remains belong to five genera—*Hylonomus*, *Baphetes*, *Dendrerpeton*, *Hylerpeton*, and *Eosaurus*; but the invertebrata are represented only by a *Myriapod* and a *Pupa*, with possibly some insect-remains. The vertebrate fossils were discovered, in the first instance, in the interior of trunks of trees, by Sir Charles Lyell and the author; but the remains of *Eosaurus* (two vertebræ only) have been since discovered by Mr. O. C. Marsh.

Respecting the affinities of the vertebrata—the most important subject treated — it may be briefly stated that Dr. Dawson refers *Baphetes* and *Dendrerpeton* to the Labyrinthodonts, *Hylerpeton* doubtfully to the Archegosaurians, and *Hylonomus* to a new order (*Microsauria*), which he does not define; while to *Eosaurus* he does not assign a place.

* Our limited space compels us to postpone the consideration of the succeeding numbers of 'The Geological Magazine.'

The uncertainty as to the zoological position of the last-named animal has reference only to the order, for it certainly belongs, as do the orders *Labyrinthodontia* and *Archegosauria*, to the class AMPHIBIA (included with the REPTILIA by Dr. Dawson); and as regards the new order *Microsauria*, Dr. Dawson states that it "may be regarded as allied, on the one hand, to certain of the humbler lizards, as the gecko or agama, and on the other, to the tailed batrachians." If this be so, *Hylonomus* must have a special interest for the naturalist, as forming a connecting link between two classes of the vertebrata. But the author also states that the genus *Hylerpeton*, though referred by him, with some doubt, to the order *Archegosauria*, "may possibly be a link of connection between the *Microsauria* and the *Archegosauria*."

As these fossils were discovered in association with a mollusk belonging to a genus (*Pupa*) which exists at the present day, and to an order (*Pulmonata*) not otherwise known to occur in beds below the Purbeck, and in the same strata as a myriapod, whose next oldest known representative was found in Jurassic strata, their examination and description naturally led Dr. Dawson to discuss their bearing upon Mr. Darwin's hypothesis of the origin of species. Accordingly the author devotes a chapter to this subject, with which, of course, he has no great sympathy; and we imagine that he refers to this part of his memoir when, in his introduction, he threatens to indulge in gossip without scruple, for we have certainly failed to detect the promised "gossip" anywhere else.

The first part of Professor Owen's "Memoir on the Cavern of Bruniquel and its Organic Contents" was read before the Royal Society on June 9th; it contained descriptions of the human remains found in the cave, and an account of the circumstances under which they were discovered; the contemporaneity of the human remains with those of the extinct and other animals, and the bone and flint implements with which they are associated, being inferred from the similarity of their position and relations in the surrounding breccia, and from the chemical constitution of the human bones corresponding with that of the other animal remains.

Several small portions of human crania were noticed by the author, and more particularly the hinder portion of a cranium, with several other parts of the same skeleton, which were so situated as to indicate that the body had been interred in a crouching posture; also, an almost entire calvarium was described, and then compared with different types of skull, being found to correspond best with the Celtic type. Certain jaws and teeth of individuals were next noticed, especially the lower jaw and teeth of an adult, and upper and lower jaws of children, the latter showing the characters of certain deciduous teeth.

The geological value of this large and unique collection of fossil human remains depends entirely upon its age, and as that can be determined only after a careful examination of the bones associated with them, we must be content to wait patiently for the reading of the second part of this memoir before arriving at a conclusion.

The most complete work that has yet appeared on the geology of Madeira has just been published at Leipzig; it is entitled 'Geologische Beschreibung der Inseln Madeira und Porto Santo,' von G. Hartung; and it contains also descriptions of the fossils by Dr. Karl Mayer. It is the result of several years' investigation of the geology of the island, begun in 1853 in company with Sir Charles Lyell, and since continued by the advice of that distinguished geologist.

Dr. Hartung first describes the different stratified and volcanic rocks composing the islands of Madeira and Porto Santo, the forms of the hills, and the results of marine and sub-aërial erosion, or denudation; but the greater part of the work is taken up with a detailed description of the various peaks, cones, and craters, this part of the subject being well illustrated by lithographed views of the localities, coast-sections of the volcanic cones, and maps of the islands, though the latter are unfortunately not coloured geologically.

Dr. Karl Mayer gives, in the concluding chapter, a full account of the results of his examination of the tertiary fossils of Madeira, and his comparison of them with those from the Azores, and from European localities the strata of which have a well-defined horizon. He differs in some respects from most other palæontologists, and we think he has assigned to the Madeira strata too remote an age in considering them to be of the horizon of Swiss Miocene, for out of 208 species determined by him 72 are recent; and although 91 species (only 9 of which are characteristic) are found in the "Helvetian" formation, yet 80 are found in the "Mayencien" below, and 83 in the "Tortonien" above, the numbers being so nearly alike that the difference may be due to accident, and the percentage of recent forms (35) being far too great for the "Helvetian" strata.

About two years ago geologists were not a little surprised at an announcement made by Dr. H. B. Geinitz, of Dresden, an eminent palæontologist, that he had discovered a Trilobite in the collection of Madame Kablik, from the Rothliegende of Nieder-Stepanitz, near Hohenelbe, which he had therefore named *Dalmanites Kablikæ*; with it was associated another crustacean, to which he gave the name *Kablikia dyadica*. Both fossils occurred in a black micaceous clay-slate, not distinguishable from a similar rock occurring at Nieder-Stepanitz, and therefore Dr. Geinitz felt certain that Madame Kablik was neither deceived nor deceiving when she assured him that it came from that locality. The word of a lady, aided perhaps by her looks, was sufficient to upset Dr. Geinitz's faith in palæontology, its laws and its facts; but other palæontologists, far removed from the personal influence of the fair collector, were sufficiently prosaic to put the veto of their calmer judgments on the validity of the asserted fact. Dr. Geinitz, stimulated by the discovery of a more perfect specimen in the lady's cabinet, set about confounding his compeers; but "facts are stubborn things," and he therefore gradually became convinced that his *Dalmanites Kablikæ* was none other than the *Placoparia Zippei*, Böck, sp. — a species which occurs in the old *Silurian* slates of Dobrotivá, near Beraun! Dr. Geinitz lingers lovingly over his

Dalmanites Kablikæ before consigning it to its grave, and then laments that *Kablikia dyadica* must be "degraded" to *Kablikia silurica!* This result of the "unangenehme Täuschung" is stolidly described in the recently published 'Sitzungsberichte der natur-wissenschaftliche Gesellschaft Isis zu Dresden' for 1863 (p. 50). We give the page because, like the works of Mr. Carlyle's 'Dryasdust,' the "Isis" has no index.

All geologists feel themselves participators in some degree in the honour which has just been conferred by Her Majesty upon Sir Charles Lyell, who has recently been created a baronet of the United Kingdom, under the title of Sir Charles Lyell, Baronet, of Kinnordy, in the county of Forfar; and we feel certain that the general public is equally pleased that this mark of distinction should have been bestowed by the Queen upon a *savant* who has so often and so ably assisted them to a clear and philosophical comprehension of geological phenomena and their causes.

Progress of the Geological Survey of the United Kingdom.

In our last number we gave an outline of the progress of the Ordnance Survey of these islands, and we now propose to supplement that sketch with an account of the origin and progress of that survey, the object of which is to portray on the Ordnance maps the mineral composition of the surface. It will be evident, therefore, that a correct topographical survey must precede, and form the basis of, a correct geological survey. Now it so happened that a few years after the detailed mapping of the Ordnance surveyors had been commenced in the south of England, the value of geological surveys began to be recognized by the Government of this country, as well as by those of several European states. It was felt that if the area occupied by each geological formation, representing, as is generally the case, some special group of minerals, could be accurately depicted, by colouring on maps of sufficient size, we should be able to arrive at an approximate knowledge of the mineral resources of the country. In the case of the coal-fields, such knowledge would be specially valuable, as forming the basis for correct estimates of our coal-resources. But there are other minerals and rocks only second in value to coal, such as the iron-formation of the Oolitic period, the limestones of the carboniferous, and the slates of the Silurian, and it was wisely determined from the commencement that in the national survey all formations alike should receive equal care and attention, and that the maps should be equally reliable as guides for the miner, the agriculturist, or the man of science.

The Geological Survey of Great Britain had its origin in the indomitable perseverance of its first director-general, Sir H. T. De la Beche. This accomplished naturalist, originally brought up for the army, early turned his attention to science, his mind having been probably attracted to geology by his residence at Lyme Regis, where the

cliffs of lias afford to the collector such rich treasures of past living forms. His love of geology increased with his years, and seems to have been especially marked by an appreciation of its practical bearings. Having left the army and arranged his private affairs, he commenced with the whole force of his character to elaborate those plans for a national survey, which he lived to see crowned with success. Being firmly convinced of the importance of a geological survey, on the basis of the Ordnance maps, he determined on a plan which involved no little cost of labour and money to himself, in order to bring the subject forcibly before the leading statesmen of the day. He consequently commenced to trace on the Ordnance maps of Cornwall the boundaries of the geological formations, as well as to insert the mineral veins, dykes, and other phenomena; and having drawn up illustrative sections, "he thus took a first step," to quote the words of his successor, Sir R. I. Murchison, "in leading public men to see the good which must result from the extensive application of such a scheme." Having by this means succeeded in inducing the Government of the day to grant a sum for the support of a limited number of assistants, the Geological Survey was established as a branch of the Ordnance. The grant once made has been gradually augmented, so as to allow the employment of a larger staff of surveyors than was at first contemplated, and the whole undertaking, after having been dissociated from the Ordnance, has at length been placed under the Science and Art department of the Committee of Council on Education.

While pursuing his investigations in the mining districts of Cornwall, Sir H. De la Beche became "forcibly impressed" with the conviction that the survey presented an opportunity not likely to recur of illustrating the useful application of geology, and he in consequence represented to Mr. Spring Rice (afterwards Lord Monteagle), then Chancellor of the Exchequer, that a collection should be formed and placed under the office of the Board of Works, comprising specimens of various mineral substances used in the construction of roads, buildings, and public works, as well as minerals, and models of machinery used in mining, the whole to be tabulated and arranged for easy reference, and thus to illustrate at a glance the mineral resources and mining enterprise of the United Kingdom. Government having acquiesced, the Museum in Craig's Court was appropriated for the purpose. Specimens rapidly flowed in, and the small building was speedily filled. A larger structure was urgently needed, and the director having succeeded in convincing Sir Robert Peel that the dignity and interests of the country required that an adequate and appropriate structure should be erected for the exhibition of the mineral treasures with which it abounds, the present Museum of Practical Geology was founded. "Then arose," to use again the language of the present director-general, "and very much after the design of Sir H. De la Beche himself, that well-adapted edifice in Jermyn Street, which, to the imperishable credit of its founders, stands forth as the first palace ever raised from the ground in Britain which is entirely devoted to the advancement of science." Indeed, when we recollect that the value of the minerals raised in the United Kingdom

amounted for the year 1851 to 24,000,000*l.*, it will be admitted that the time had arrived for the erection of a building in some degree proportionate to the position occupied by this country in mining enterprise.

The next step was the establishment of a school of mines. Although in 1851 the mineral produce of this country was calculated at four-ninths of that derived from all Europe, no school having for its object the instruction of persons engaged in mining operations had been established up to that year in the United Kingdom. In this respect other countries had been in advance of ours. France, Russia, Prussia, Saxony, Austria, Spain, Sweden, Denmark, and others even less connected with mining industry, were furnished with schools of mining by their respective governments. The consequence was, that in the theoretical branches of mining we were often far behind. In many quarters there existed a prejudice against the application of science to mining, as though theory and practice were necessarily opposed to each other; and young men who wished to acquire the former as well as the latter, were obliged to go to the schools at Freiburg and elsewhere, in order to be instructed in the rudiments of their profession. A committee of the House of Lords at length reported (1849) in favour of the establishment of a Government school of mines, and the Museum of Practical Geology was fixed upon as the proper centre for its operations. The inauguration took place in 1851, and along with the Geological Survey, the school was placed under the direction of Sir H. De la Beche. The edifice was thus complete in all its details, but he who was the master-builder did not long survive to see the fruits of his labours. A premature decay of his physical powers set in, and he died in 1858, regretted alike by the scientific world and by his own immediate friends, and leaving the department over which he presided to the care of its present director-general, Sir R. I. Murchison.

The progress of the Geological Survey has been, on the whole, from the south and west of England towards the north and east, or from the older to the newer formations. The first maps completed were those of Cornwall and Devon; these in all probability will require a fresh survey, owing to the advance of the science of geology within the last quarter of a century, and the greater attention to minutiæ which has been introduced into the works of the survey, as evinced by the tracing of several subdivisions in the New Red Sandstone and Millstone grit formations of the central counties. In South Wales the Survey had the advantage of the labours of Sir William Logan, now director of the Geological Survey of Canada, who had, previous to the year 1840, collected a vast amount of information relating to the South Wales coal-field, which, together with the maps and sections he had constructed, he placed at the disposal of the director-general. This vast tract of Carboniferous rocks, embracing portions of several counties, rising into lofty table-lands, and penetrated by valleys of unusual depth, is one of the marvels of our country. Having an area of 900 square miles, and with seams of coal descending to depths of several thousand feet, there can be no doubt regarding the almost

unbounded resources of its minerals, which well deserve all the labour that may be required for their elucidation. Professor Ramsay, in his inaugural address at the School of Mines in 1857, states that after the publication of the maps of that country, landowners, colliery proprietors, coal viewers, and mining engineers all acknowledged their importance, and that a gentleman well versed in mining and scientific geology observed to him, "that the publication of the Government maps had placed them" (the colliery proprietors of South Wales) "thirty years in advance of what they were before."

The disentanglement of the geological intricacies of North Wales was a work requiring a more than ordinary amount of skill and perseverance. In many places the slaty rocks and grits are repeatedly broken by faults, traversed by dykes of igneous rocks, or metamorphosed by enormous protrusions of trap, or old sub-marine lava-flows. To trace out on the small one-inch maps of the Ordnance Survey each particular dyke, band of slate, or bed of limestone, amongst wild tracts of moorland or precipitous ranges of mountains, with few objects to guide the surveyor in determining his position, and often obliged to carry on his work amidst seething mists or pitiless storms, at other times puzzled to determine the very nature of a rock in regions where the characters and aspects of the formations are as changeable as the colour of the sky overhead, and when the whole structure of the beds is suddenly disarranged and thrown into disorder by the occurrence of a fault or dyke,—out of all this chaos to evoke order and system, and in spite of all obstacles to produce the geological maps which are now in the hands of the public,—was a work which we venture to think has never yet been fully appreciated except by the very few field-geologists who have made attempts at similar undertakings. It cannot, however, be otherwise than gratifying to those gentlemen who have been engaged in the survey of this and other parts of the kingdom, to find one of the most influential newspapers in the North of England recognizing the merits of the survey in a leading article, in such language as the following:—"The manner in which this geological picture of the kingdom has been executed, commands the admiration of all competent judges. At the Paris Exhibition of 1855, the map, as far as it was then completed, was admitted by the geologists and miners from all parts of Europe who flocked thither, to be the finest work of the kind yet achieved, and elicited general praise for its detailed truth and precision in the delineation of those dislocations of the crust of the earth, the tracing out of which is so laborious, and can be accomplished only by men of profound science."*

The survey of the Midland and Western counties of England has been completed, embracing several of the most important coal-fields, and those tracts of the newer formations under which the coal is considered to be hid, and which may be regarded as reserves of mineral fuel kept in store for the use of future generations. It is hoped that the labours of the survey will throw light on the question of the position and depth of the beds of coal under the Triassic and Permian

* 'Manchester Guardian,' 27th July, 1864.

formations over considerable areas. Of the most important coal-fields, those already completed are the following:—North and South Wales, Bristol and Somersetshire, Forest of Dean, Forest of Wyre, Coalbrook Dale, North and South Staffordshire, South Lancashire (on the 1-inch and 6-inch scales), Warwickshire, Leicestershire, Derbyshire, and part of Yorkshire. In Scotland the coal-fields of the Lothians and Fifeshire have been published on the two scales above mentioned; and in Ireland several of the coal tracts, economically of small importance, have also been examined.

The importance of completing the survey of the country surrounding the metropolis has for the last few years been steadily kept in view, so that the "London basin" has been completely enclosed, together with the rich district of the Weald of Kent to the south of it. As the Chalk and Greensand formations may be regarded as reservoirs of water, which are even now very largely drawn upon by the Artesian wells of the city, the accurate delineation of the extent of these water-bearing formations possesses more than a mere scientific interest.

Having completed that part of England which may be described as lying to the west of the line of the Great Northern Railway, and south of the valley of the Thames, the course of the survey would, under ordinary circumstances, have extended into the purest agricultural district of the Eastern counties. Here the geological maps could have possessed little or no economic value. This being so, it has been represented very forcibly to the director-general (as we learn from the report for 1863) that there would be greater practical utility in employing the staff of surveyors on the remaining Northern counties, so rich in their stores of coal, iron, and other minerals of the Palæozoic age, while the Eastern counties, formed of drift-covered strata of the Secondary and Tertiary periods, might be allowed to wait till after the completion of the former. Sir Roderick Murchison states that he has recognized the force of these representations, so that we may expect the six Northern counties, with their important coal-fields, will in the course of a few years be geologically portrayed on the Ordnance maps.

An important branch of the Geological Survey is the preparation of vertical and horizontal sections; the former for the purpose of showing in columns, on a scale of 40 feet to an inch, the vertical succession of the strata; the latter to illustrate the geological structure of a particular line of country, down to a natural scale of 6 inches to a mile, and with a datum of the sea-level, or a thousand feet below. The horizontal sections are all actually levelled, and represent in outline the *natural* features of the country; not the distorted undulations of a railway section. In these sections the outcrops of the coal-seams, the boundaries of the formations, and the faults are shown in their true places as far as can be determined, and thus we obtain a representation of the interior of the earth as it would appear if laid open along this line down to the level of the sea, or lower. In Wales and other districts, the sections have been carried across the highest mountains, and give a faithful outline of the surface along definite tracts of country or across precipitous descents, where the most adventurous climber seldom dares to tread.

The immediate direction of the field-work of the British survey is in the hands of Professor Ramsay, F.R.S., to whose close attention to accuracy of detail, combined with a profound acquaintance with physical geology, the trustworthy character of the maps and sections is greatly due. The Irish survey, under the able management of Mr. Jukes, F.R.S., is also making rapid progress. During the past year 1,453 square miles were surveyed in Great Britain, and 818 square miles in Ireland, portions of these being re-surveys of the superficial drift accumulations.

Complaints have sometimes been made, and with some show of justice, of the slow progress of the British surveys. This has been mainly owing to two causes. In the first place, for several years after the survey had been set on foot, under Sir H. De la Beche, a very small number of surveyors, not exceeding half-a-dozen, was allowed by the Government to be employed at one time. In the course of time the staff was gradually increased, and this source of delay may now be said to have been surmounted. The second cause is still in existence, namely, the low scale of remuneration granted by Government to the surveyors. We have no hesitation in saying this is short-sighted policy, and will eventually result in a larger outlay of the public funds. The result, as proved in many cases, is that the young surveyor, as soon as he has passed through a couple of years or so of training in the field, which is in every case necessary, and is ready to commence operations on his own resources, is tempted to accept the first offer of a surveyorship in the colonies, or any other opening that presents the prospects of a competency. Thus the public lose the benefit of his services soon after he has become capable of rendering them. Under the present scale of remuneration this branch of the public service (in common with another connected with the same department of the state, namely, the "Science Teacher") can only be regarded as a stepping-stone to some more substantial source of livelihood, as it is scarcely possible the Surveyor can save out of his income, or that his physical strength will withstand the wear and tear to which he is exposed till the age at which he is entitled to retire on a pension.

VI. MICROSCOPY.

The history of embryological science dates from the invention of the microscope, and has advanced *pari passu* with the improvements of that instrument and the facilities afforded to microscopical observers.

Dr. C. Robin has lately directed his attention to the development of the spinal column from its earliest stages with some important results. He has succeeded in showing that the atlas and axis vertebræ offer this peculiarity, that the first constitutes a vertebral ring without a body, whilst the second has two vertebral bodies united in one. The odontoid apophysis, in fact, is nothing more nor less than the body of the atlas, which during the processes of development becomes thus sepa-

rated from its proper connection, and gives rise to that wonderful piece of mechanism met with in the cervical region of the mammalian class. When the mammalian embryo is from four to six millimetres in length, the observations are commenced. The guinea-pig, rabbit, rat, dog, sheep, pig, cow, and human fœtus have all been submitted to examination by the author. At the early period when the embryo has this size, the cartilages of the first three or four thoracic vertebræ may be observed situated near the middle of the notochord. They increase rapidly in number, both in the anterior and posterior directions, until the number of twenty-four is attained; the sacral and coccygean bodies appear later. The vertebral bodies are separated from one another by regular spaces or intervals, traversed by the notochord. This, after a time, dilates in these interposed spaces and becomes fusiform, afterwards becoming flaccid and surrounded by a viscid fluid, thus giving rise to the intervertebral tissue. Although the vertebral cartilages are the first to appear in the body, yet the cartilage of the axis does not appear in the guinea-pig until it has attained a length of eleven millimetres. This cartilage originates in two distinct pieces, the anterior of which evidently belongs to the atlas. They unite to form the single body of the axis vertebra before ossification has commenced and whilst yet in a purely-cartilaginous condition. In the human fœtus the unison takes place when the length is about fourteen millimetres. The ossification of the two vertebræ and the anomalies observed in various species of Mammalia are treated of at some length by M. Robin. His decision as to the nature of odontoid process is beyond controversy, and has established a fact for many years denied by some physiologists.

M. Pouchet has lately published some observations connected with spontaneous fission in Infusoria. He considers this a much rarer phenomenon than is usually affirmed; and with regard to the *Vorticellæ*, states that during twenty years' observation he has failed to detect a single instance of fissiparity in these animalcules. A monstrosity with two bells on a single stalk has been often mistaken for the commencement of fission; whilst it frequently occurs that a free vorticellid attaches itself to the bell-shaped body of a fixed individual, and is another source of error.

M. Elias Mecznikow has described, in Du Bois-Raymond's 'Archiv.,' a new form of the genus *Sphærophrya*, the connection of this acinetiform animalcule with the Paramæcia being illustrated by a series of very beautiful drawings.

Professor Gulliver continues his interesting researches on Raphides. Should he be enabled to extend his researches sufficiently, a very important test would be afforded to the analytical microscopist, as regards the adulteration of vegetable articles of commerce.

M. N. Lieberkuhn has published some interesting observations on the changes occurring in Sponges after death. It appears that in the species he observed, the whole sponge does not die, but parts fall away and decay; other portions emit prolongations, which become detached and remain at the bottom of the vessel in which they are kept. When observed under the microscope, they are seen to be provided with

vibratile cilia, and contain siliceous spicules; some portions emit processes similar to those of Actinophrys, others become encysted. From the cysts from four to five monads emerge, provided with a single whip, and capable of swimming or performing amœbiform movements. Similar monads have been observed in the eggs of other low forms of invertebrates.

Researches conducted with the aid of the microscope will doubtless explain many strange phenomena, and place many facts within our comprehension which, before, were veiled in mystery. The discovery of fatty degeneration of the heart and liver has accounted for sudden deaths, which are of frequent occurrence, and where no diseased condition of body is perceptible to the unassisted eye. It appears, however, from the researches of M. Tigri, recently published in the 'Comptes Rendus,' that this disease extends to the blood itself. A fatty substance has been found to accumulate in the red blood-corpuscles which materially influences the circulation, and in the opinion of the author frequently produces death.

Dr. T. F. Weisse, of St. Petersburg, gives a detailed account of the development of the eggs of *Floscularia ornata*, in the last number of Kölliker's 'Zeitschrift.' Whilst the author was engaged in investigating the eggs of the Rotifera, he discovered a beautiful example of *Floscularia ornata* in his aquarium, which had already deposited four ova; a fifth was afterwards expelled from the animal under observation by forcible contraction of the body. The germinal vesicle was still observable in this last ovum. No remarkable change took place in the ova for two days, until in one a bright red spot was observed, and on the following day two distinct eyes, which moved with the already-visible embryo; other changes were observed in the course of the day; ciliary motion appeared near one end of the embryo, and the pharynx exhibited movements at times. At the end of five days, the ovum was ruptured and the little animal issued from its shell, using a worm-like movement and showing clearly the circle of cilia at its anterior extremity. A figure is given of the embryo at this period, when it bears not the least resemblance to the parent, and would easily be considered as a distinct species of animal. The development appears to take a considerably longer period than was generally supposed to obtain among the Rotifera. M. Weisse believes seven days to be the period passed by this species in the ovum after emission from the parent's body.

The application of photography to the delineation of objects beneath the microscope does not advance in that rapid manner, or receive the amount of attention, which is to be desired. There can be no surer method of settling many disputed points of structural anatomy than the circulation of well-executed photographs of the objects under discussion. M. Duchenne, of Boulogne, has succeeded in obtaining some very accurate photographs of the microscopic appearances of the spinal chord of the human subject. The magnifying power used in obtaining these photographs was from 200 to 1,000 diameters.

Dr. Clark, of Harvard University, has described the eggs of *Tubularia*, in 'Silliman's Journal,' vol. xxxvii. His observations have led

to some very interesting results. The eggs of *Tubularia* have hitherto escaped the attention of naturalists. Dr. Clark accounts for this by the extreme minuteness of the ova, which he was unable to detect with a power less than the ¼-inch.

VII. MINING, MINERALOGY, AND METALLURGY.

Mining.

For some years past there have issued from the 'Mining Record Office,' one of the Departments connected with the Museum of Practical Geology, very complete returns of the value of our mineral productions. From these "mineral statistics" we learn the total value of our mineral produce in 1863 to have been 29,151,976*l.*, which, when brought into the metallic state, at the actual cost of manufacture, was increased to 36,364,327*l.** The more important minerals were the following:—

	Tons.	Value at place of production.
Coal . . .	86,292,215	£20,572,945
Iron ore . . .	9,101,552	3,240,890
Tin	15,157	963,985
Copper . . .	210,947	1,100,554
Lead . . .	91,283	1,193,530

The quantities and values of the metals obtained from these being:—

	Tons.	Value.
Iron, Pig . .	4,510,040	£11,275,100
Tin . . .	10,006	1,170,702
Copper . . .	14,247	1,409,608
Lead . . .	68,220	1,418,985
Silver obtained from the lead . ounces	634,004	174,351

In addition to the above, returns are given of zinc, sulphur ores, wolfram, arsenic, and other minerals, showing in detail, the actual value of every mining district in the United Kingdom.

By the issue of these annual statistics, and by preserving records of all our subterranean operations, the Mining Record Office is rendering important service to all our miners and manufacturers.

The production of gold from the quartz lodes of the Cambrian mountains shows a considerable falling off during 1863, the total produce for the year being 552 oz. 12 dwts. and 19 gr. only. The prospects, this year, are however much more promising. The following is a return made on the 13th August:—At Castell Carn Dochan 5 oz. and 12 dwts. of gold were obtained from 20 cwt. of quartz from the lode and alluvial matter; this makes a total of about 50 ounces obtained from that mine during this year. At the Welsh gold mine it

* 'Mineral Statistics of the United Kingdom of Great Britain and Ireland' for the year 1863, with an Appendix. By Robert Hunt, F.R.S. Published by order of the Lords Commissioners of Her Majesty's Treasury.

is said that 66 ounces of gold were obtained from 44 cwt. of quartz; and about two cubic yards gave 7 lbs. of gold. At the Prince of Wales a new discovery is stated to have been made: and at the old Clogau copper mine the quartz yields about 1 oz. of gold to the ton.*

The reports of the Government Inspectors of Collieries for 1863 have been published. They are satisfactory as compared with the previous year, which was unusually disastrous, and also as compared with 1861. The following tabulated summary of the deaths of colliers will place the number and character of the accidents at once before the reader:—

	1862.	1863.
Explosions of fire-damp . . .	190	163
Falls of roof and coal, &c. . . .	422	407
In shafts	137	147
Miscellaneous accidents under-ground and at surface	384	190

This last return—for 1862—includes the number sacrificed by the Hartley casualty, by which 204 men were lost. The total deaths in collieries in 1862 was 1,133, the deaths in 1863 being 907, or 226 less.

It is admitted, on all sides, that the only method promising to improve permanently the condition of our mining population, and by improving the miner to lessen the number of accidents in working our mines and collieries, is to be sought in an improved education. Miners at present, for the most part, are entirely uninstructed in any of the principles involved in their labours. They are expected to use the precautions which science tells us should be employed, and yet we make no effort to teach them what those precautions are, or on what principles they depend. A safety lamp is placed in the hands of a collier without his knowing one of the conditions which makes it a *safety* lamp. Yet the moment an ignorant man tampers with the wire gauze he is punished. Surely this is not consistent with reason or justice. It is to be regretted that one of the most promising experiments towards educating the working miner is abandoned. The Glasgow School of Mines is shut up, subscriptions from the coal and iron masters of that wealthy district having entirely failed. We fear the British Mining School cannot be long continued; and the Miners' Association of Cornwall and Devonshire does not appear to be in a healthful state. Surely, in a country producing minerals to the value of nearly thirty millions sterling, there should be found establishments in which so much of science as can be directly applied by the miner with advantage to his labours, might be obtained at small cost, and with but little sacrifice of time. The Royal School of Mines, as a central establishment, is all that can be desired; but local schools in connection with it should be at once established.

The application of machines to the cutting of coal appears to be becoming general. Several new patents have been obtained. One by Mr. Harrison, of Tudhoe Iron Works, is well spoken of, but we have

* 'Mining Journal,' August 13, 1864.

not yet been made acquainted with any practical results which will admit of our comparing it with those which we have already described.

Much attention has recently been given to mining-powder, with a view to increase its disruptive power, and produce it at a cheaper rate. M. Nobel states that by damping mining powder with nitroglycerine its explosive power is trebled, and the noise of the explosion much less than when ordinary powder is used. One firm is making blasting-powder with nitrate of soda instead of nitrate of potash, by which the cost is reduced one-third, but this powder has the objection of a tendency to deliquescence unless it is very carefully kept. In another powder, the spent tan of the tanners' yards is substituted for charcoal, and an increased activity given to the composition by the addition of a little chlorate of potassium. This explosive powder is said to have a considerable amount of disruptive power; in price it stands about equal to that manufactured with nitrate of soda.

A composition for mining purposes is now being subjected to experimental trial in some of the mines near Tavistock, in Devonshire. The peculiarity of this is, that the materials which constitute it are kept apart, or at least in two parcels, neither of which are in themselves explosive. They become so, however, on being mixed in certain defined proportions, which is not done until the moment of its being placed in the holes. The actual composition of this explosive agent is not stated, but it must of necessity consist of carbonaceous matter in one parcel, and of some agent which rapidly developes oxygen—as nitre or chlorate of potassium — in the other. At the request of Lord Kinnaird, the chairman of the Mines Commission, a series of experiments has been made in Dolcoath and some other mines with gun-cotton, as manufactured by the Austrian process. The results were satisfactory as regarded its explosive power and the absence of *visible* smoke. Dr. Angus Smith and Dr. Bernays are engaged in the analysis of the air collected in the mines before and after the explosions. The report of the Commission will contain these analyses, and much special information on the use of gun-cotton in mines. Mr. John Scott Russell's paper on "Gun-cotton," in the last number of 'The Journal of Science,' contains all the most recent information on this explosive compound.

Mineralogy.

W. C. Bischoff* has shown that the basic silicates of alumina are more refractory than the acid silicates. Alumina artificially obtained and chemically pure, is less refractory than chemically pure silica; but natural alumina is more refractory than natural silica as found in quartz rock-crystal and amethyst. Herr Bischoff has also discovered that the mineral pyrolusite may probably be found to be a new source of the rare metal *thallium*, a specimen in his collection giving 1 per cent. of this new element.

H. Haidinger has communicated† to the Académie Impériale des

* 'Journal d'Erdmann et Werther.' 'Annales de Chimie.'

† 'Ann. der Chem. und Pharm,' vol. cxxix. p. 375.

Sciences de Vienne his continued researches on "Metallic Irons which are probably non-Meteoric." This examination is of the utmost importance, as tending to the settlement of a vexed question. We have no doubt but many of the masses of "meteoric iron" so called, to which attention has been directed, will be found to be of terrestrial origin. We reserve, until the inquiry is yet further advanced, any extended notice of these investigations. It is sufficient to state, at present, that MM. Haidinger and Hornes consider that they have proofs that many of the specimens in the Imperial Museum of Vienna are not of meteoric origin. There can be no doubt but that many of the masses of iron reputed to be meteoric are so in reality; indeed, we appear to possess good evidence of the actual observation of their fall. It is, however, a question deserving serious inquiry, whether every mass of native iron containing manganese, cobalt, and nickel is of atmospheric origin.

M. Cloëz and M. Pisani Lowe both instituted a very careful analysis of the aërolithe of Orgueil. In many respects this meteoric stone is found to resemble the mineral Serpentine, analysis giving the following constitution:—Silica 26·08, magnesia 17·00, protoxide of iron 21·60, lime 1·85, soda 2·26. potash 0·19, oxide of manganese 0·36, alumina 0·90, chromate of iron 0·49, oxide of nickel (with cobalt) 2·26, sulphuric acid 1·54, hyposulphuric acid 0·53, chlorine 0·08, sulphur 5·75.*

In connection with the inquiry on meteoric stones, M. Haidinger and others have investigated all the conditions under which graphite occurs in nature.

A report has been published,† from which we make a few extracts:—

"One word on the formation, still so little known, of graphite (plumbago, pencil lead). The presence of graphite in granite, gneiss, and diorite has renewed the disputes between the Neptunists and Plutonists. Graphite is well known to be nearly pure carbon, for it leaves in burning but a very small quantity of ash. Now, if these primitive crystalline rocks are of igneous formation, it is impossible to explain how graphite could co-exist with silicates of protoxide of iron without having reduced these salts. Judging merely by what takes place in blast furnaces, carbon reduces all oxides of iron at a high temperature. It must then be admitted that granite, gneiss, and diorite did not contain graphite when the mineral elements of these rocks, such as mica, hornblende, and other ferrous silicates, were in a state of fusion. Graphite then must have been subsequently introduced into these rocks, but when, and how? Questions such as these are very difficult to answer satisfactorily. The most plausible hypothesis is that graphite has been introduced by the wet way into the crystalline rocks and substituted for one of the mineral components. Thus in the gneiss of Nassau (Bavaria) it takes the place of mica.

"Graphite is frequently to be met with in granulated limestone, a fact particularly interesting to geologists. Is limestone a product of eruption, or is it a sediment transformed by the action of heat? The presence of graphite is explicable by neither hypothesis. For at a certain temperature, which need not be very high, carbon decomposes carbonate of lime.

* 'L'Institut,' August 10, 1864.

† See 'Cosmos,' pp. 720, 725, 1864, and 'The Chemical News,' August 6, 1864.

This salt may, no doubt, under strong pressure be heated to the melting point without losing its carbonic acid; this is a laboratory experiment often cited by the Plutonists; but it is quite a different thing with a mixture of carbon and carbonate of lime at a high temperature. If we reject the Neptunian origin of granulated limestone, we must then, as with crystalline rocks, suppose that graphite has been introduced by the wet way at a more recent period. The same remark applies to magnetic pyrites (sulphide of iron) often very rich in plumbago kerns. Does graphite, like all carbon, belong to the organic kingdom? It is certain that anthracite, lignite, coal, are the result of the slow decomposition of an enormous quantity of vegetables. The impressions found on them often indicate the kind of vegetables, most of them extinct, which have contributed to these carbonaceous formations. Graphite, if not formed in precisely the same way as coal and anthracite, nevertheless bears signs of an organic origin. The formation of nuclei and veins of graphite in crystalline rocks is sufficiently explained by the decomposition of carbonized hydrogen gas at a high temperature; this gas, disengaged from organic matters, and penetrating the fissures of the burning rock, would undergo decomposition into hydrogen and carbon.

"It is this deposited carbon which forms graphite. If in our laboratories we do not obtain exactly the same product, it must be remembered that nature has means at her command which escape our researches. We find it impossible to make coal from wood. The wood may be carbonized by the dry or by the wet way. In the first case the carbonization is very rapid; in the latter it is extremely slow, as is shown by the blackened points of piling sunk in water. Finally, graphite has been found in meteorites or aërolites. Attempts have been made to explain its presence here by the continuance of these stones in soil more or less rich in carbonized principles. But with regard to newly-fallen stones, this explanation is inadmissible. If it be maintained that graphite is an organic product, it must be admitted that in the case of newly-fallen meteorites it can proceed only from organic matters belonging to another world than our own."

A very interesting account of the mode of occurrence of the emeralds of Salsburg has been lately communicated to the Imperial Institute of Geology at Vienna, by M. Lipold. These emeralds are found in the valley of Habach, in the district of Haut-Pinzgau. The locality in which they are discovered is 2,212 metres (of rather more than 39 inches) above the level of the Adriatic. These emeralds are cemented in a mica schist which is regularly bedded in the great system of the crystalline schists of the central Alps, passing on one side into a talcose schist, and on the other to a very fine grained gneiss, rich in mica. In each of those the emeralds are found inclosed. The bed of emeralds has been opened upon for the length of 227 metres, with a thickness of from 2 to 4 metres. These emeralds have usually the form of prisms with six faces, and are either of a deep dark-green, or of an apple-green colour. Stones of a fine green colour and free from flaws are rare. The largest which have yet been found have been about 13 centimetres (the English inch is about $2\frac{1}{2}$ centimetres) in thickness and 52 centimetres in length.

M. Henri Ste. Claire Deville communicated to the Académie des Sciences a note from M. Wœhler, in which he relates some experiments which appear to show that M. Lewy was not quite correct in stating

that the colour of the emerald was due to organic matter. M. Lewy was led to believe that this was the case, as the gem appeared to lose colour on the application of heat. M. Wœhler does not find this to be the case; and he imparts a similar colour to glass by the use of chromic oxide, from which he concludes that this is the colouring agent, though he does not deny the presence of some organic matter.*

Mr. H. C. Sorby, F.R.S., who has associated his name with the microscopic examination of rocks, has communicated to the Royal Society a continuation of his inquiry as directed to the structure of meteorites.† Mr. Sorby says:—

"In the first place it is important to remark, that the olivine of meteorites contains most excellent 'glass-cavities,' similar to those in the olivine of lavas, thus proving that the material was at one time in a state of igneous fusion. The olivine also contains 'gas-cavities' like those so common in volcanic minerals, thus indicating the presence of some gas or vapour." . . . "Some isolated portions of meteorite have also a structure very similar to that of stony lavas, where the shape and mutual relations of the crystals to each other prove that they were formed *in situ* on solidification." . . . "In others the constituent fragments have all the characters of broken fragments. This sometimes gives rise to a structure remarkably like that of consolidated volcanic ashes, so much, indeed, that I have specimens which, at first sight, might readily be mistaken for sections of meteorites. It would therefore appear that, after the materials of the meteorites are melted, a considerable portion was broken up into small fragments, subsequently collected together, and more or less consolidated by mechanical and chemical actions, amongst which must be classed a segregation of iron, either in the metallic state or in combination with other substances. Apparently this breaking up occurred in some cases when the melted matter had become crystalline, but in others the forms of the particles lead me to conclude that it was broken up into detached globules while still melted. This seems to have been the origin of some of the round grains met with in meteorites; for they occasionally still contain a considerable amount of glass, and the crystals which have been formed in it are arranged in groups radiating from one or more points on the external surface, in such a manner as to indicate that they were developed after the fragments had acquired their present spheroidal shape." . . . "There are thus certain peculiarities in physical structure which connect meteorites with volcanic rocks, and at the same time others in which they differ most characteristically."

Mr. Sorby promises a continuation of this interesting subject.

A correspondent of 'Les Mondes,'‡ from Palermo, reports the discovery, near Nicosia, in the province of Catania, of a quicksilver mine. The mineral is said to exist in great abundance.

At a recent meeting of the Académie des Sciences de Paris, M. Ste. Claire Deville presented an analysis made by M. Damour of a new and very rare mineral, to which they have given the name of *Parysite*. This mineral contains 3 equivalents of carbonic acid, 2 equivalents of oxide of cerium, 2 equivalents of oxide of lanthanium

* 'Comptes Rendus,' June 27, 1864.
† 'Philosophical Magazine,' August, 1864, p. 157.
‡ 'Les Mondes,' June, 1864.

and of didymium mixed with chloride of calcium. Its density is 4·358, and its hardness intermediate between apatite and fluor-spar.

The same industrious and intelligent chemist, whose studies in mineral chemistry are of the highest character, has communicated to the Academy some remarks on the isomorphism of arsenic and antimony. This note by Ste. Claire Deville has been elicited by the remarks made at the sittings of the Academy of Sciences in June and July. We must refer all who are interested in these mysterious actions of crystallogenic force to the papers themselves, which will be found in the 'Annalen der Chemie' and in 'L'Institut.'

Mr. T. Sterry Hunt continues his "Contributions to Lithology." He examines, first, some eruptive rocks, such as quartziferous porphyries, trachytes, &c.; he then proceeds to describe the conditions under which orthoclase porphyry and syenite occur. In these papers we have a very complete geological investigation of the subject, and a careful physical examination.*

The new metal *Indium*, so called on account of the indigo-blue line which it shows under spectroscopic examination, has been found by Reich in the black blende ore of Himmelfahrt mine, near Freiberg. Two hundred pounds of this blende (the black jack of our miners) yielded a few grammes of the new element.†

We noticed in our last a new Cornish mineral, which Professor N. S. Maskelyne had described. He has since that period exhibited this mineral at a recent meeting of the Geological Society. He proposes to call the mineral *Langite*, in honour of Professor Victor von Lang, of the University of Gratz, and formerly of the department of Mineralogy in the British Museum.

Quicksilver has been discovered in New Zealand. A correspondent of 'The Argus' (colonial paper) states that over an extensive tract on the slope of a hill, at the depth of about 5 feet, this metal is found mixed with the "wash-dirt," which is about 9 feet in depth. The gold which has been discovered in the same locality is all in the state of amalgam.

Metallurgy.

The high price of bismuth, and the scarcity of the ores of that metal, have led M. Balard to make experiments on worn-out type metal with a view to its recovery. This French chemist has been to some extent successful. By solution in nitric acid, nitrates of lead and bismuth are obtained. After rendering the solution as neutral as possible, plates of lead are placed in it, when bismuth is precipitated in a metallic state. The tin is recovered by reduction on charcoal; and the lead, as a carbonate, by precipitation with carbonate of soda.

The extraordinary price attained by this metal was due to a circumstance which would scarcely be suspected in the present day. A company was formed in London, under the direction of a foreigner,

* 'The American Journal of Science and Arts,' conducted by Professors Sillimans and Dana, July, 1864.

† 'Berg. u. Hüttenmännische Zeitung,' vol. xxiii., 1842.

for the purpose of *making gold*. Very large premises were taken, and much apparatus placed in position to carry out the most recent attempt at transmutation. Bismuth was to have entered largely into the process, and all that could be obtained was purchased by the company regardless of price. Of course, no gold has been made, and to save, out of the wreck, as much as possible, the deluded shareholders are cautiously selling their stock of bismuth, so as to obtain as high a price as possible, and thus by a legitimate process convert it into gold. Few things can show more strikingly than this does the deficiency of knowledge amongst a large and respectable class of people. It was not long since that the writer of this notice was positively told by some gentlemen, that they were about to extract aluminium from quartz, and if embarking a large sum of money in so wild a scheme may be regarded as a proof of their conviction that this was possible, that proof certainly existed. Still more recently a man supposed to be an experienced miner has returned from abroad, bringing with him what he regarded as very fine specimens of tin, whereas they are only crystals of wolfram (*tungstate of iron*), and consequently valueless. Such instances surely show the necessity of making some of the sciences part of our ordinary educational system.

It has always been a complaint that there is a considerable loss of silver in the reduction of that precious metal from the rich ores of the Mexican mines. M. Poumarède has turned his attention to this, and in a communication to the Paris Academy of Sciences he states his belief that this is due to an imperfect chloridization of the silver, and consequently irregularity of action. He states that if finely-powdered quartz be mixed with about 1 per cent. of silver powder and 2 or 3 per cent. of salt, and heated for half-an-hour to redness in a covered crucible, all the silver will be found to have passed into the form of chloride, soluble in ammonia. If the silver is in the form of sulphide, or any other compound, the same result is obtained. When, instead of quartz, we use felspar,—either with or without earthy carbonates, oxide of iron, or other constituents of the veinstone,—the same conversion into chloride takes places in an equally complete manner. The application of this in the processes of reducing silver ores is obvious.

Attention is again being directed to the combination of tungsten with steel. Some years since Mr. R. Oxland patented a process for separating wolfram (tungstate of iron) from tin, and it was proposed to employ the tungstate of soda obtained in the process as a mordant, and the metallic tungsten as an alloy with iron. M. Jacob subsequently made steel, with tungsten in its composition, and carried out some large and apparently satisfactory experiments at Sheffield and in Austria. The results were so promising that M. Jacob gained possession of nearly all the sources of wolfram in this country. For several years, however, nothing has been heard of this alloy.

Now M. Le Guen has solicited attention to what he calls *wolframed pig-iron*. Experiments have been made at Brest, and the pig tested was found to offer a greatly-increased resistance when less than 2 per cent. of wolfram had been added to the iron. Another description of pig-iron, formed of one-third of best old English pig and two-thirds of

the fragments of old cannon with German wolfram mixed in the same proportion, show an augmentation of resistance equal to about sixty-eight kilogrammes per square centimetre.* Numerous other experiments of a similar character were made, the results appearing to be, in all cases favourable to the wolframed pig-iron. There is much difference in the character of the tungstate of iron. The French wolfram, containing a little arsenic and sulphur, is not equal even after roasting to the German mineral, which is very pure.

We noticed in our last Journal Mr. Griffiths's mechanical puddler. Another patent has been obtained by Mr. Thomas Harrison, of the Tudhoe Iron Works, Ferry Hill, Durham, for "improvements in machinery for puddling iron and steel." We are not yet aware of any works at which this new arrangement has been adopted. The moment we learn the result of any trials we will communicate the same to our readers.

VIII. PHYSICS.

Light.—It might be imagined that such an obvious question as that of the relative brilliancy of various portions of the solar disc would have been definitely settled by this time; yet we find physicists still adhering to the opinion that both the centre and the circumference are equally luminous; whilst others, by far the larger majority, adduce experiments and reasonings to prove that the centre is considerably more luminous than the marginal portions of the disc. Respecting the actual *light* which comes from the sun, we are not aware that any accurate photometric experiments have yet been made, although observers have long noticed a difference in luminosity between the centre and the edge; but we find that the variations of chemical and thermic, follow so completely those of luminous intensity, that it will be admitted that what is proved of the two former holds equally good in the case of the latter. Secchi† has shown that the calorific radiation of the centre of the sun's disc is nearly double that from its borders, and that the equatorial regions are somewhat hotter than the polar. More recently, Roscoe,‡ in some carefully-conducted experiments, showed that the intensity of the chemically-active rays at the centre was from three to five times as great as that at the edge of the disc, and that the chemical brightness of the south polar regions was considerably greater than that of the north polar regions, whilst about the equator the brightness was between that of the poles. Professor Roscoe's results were obtained by exposing a prepared paper in a camera to the action of the sun's image, and comparing the shade of tint produced thereby at the centre and at the circumference with a

* A kilogramme is the fiftieth part of an English cwt., and a centimetre about four-tenths of an English inch.

† 'Astron. Nachr.' Nos. 806, 833.

‡ 'Proceedings of the Royal Society,' 1863.

certain standard. Dr. Woods* now suggests a plan which he adopted in 1854† to show the identity of the sun's action on a photographic surface with that of flame, the centre rays of the latter being also more intense in chemical action than those at the circumference. This method consists in exposing the prepared paper to the sun's picture in the camera for a period so short that the centre or most active rays only have time to act upon it; then, for the next impression, to leave the paper exposed for a somewhat longer time, so that a somewhat larger picture is obtained; and so on until the entire picture is given. The size of the impression produced would be in proportion to the time of exposure, and it would appear that the intensity of the chemical rays from any part of the disc would be more accurately fixed by getting the time required for their action than by the use of standard tints.

An important contribution to our knowledge of the light from certain of the fixed stars has been presented to the Royal Society by Mr. Huggins and Dr. Miller. These gentlemen use in their spectroscope two dense flint-glass prisms, and the spectrum is viewed through a small achromatic telescope, with a magnifying power of between five and six diameters. A plano-cylindrical lens of 14-inches focus is employed to convert the image of the star into a narrow line of light, which is made to fall upon a very fine slit, behind which is placed an achromatic collimating lens. The spectroscope so constructed is attached to the eye-end of a refracting telescope of 10-feet focal length with an 8-inch achromatic object-glass, and the whole is mounted equatorially and carried by a clock-movement. By this instrument between forty and fifty of the fixed stars have been more or less completely examined, and tables of the measures of about 90 lines in *Aldebaran*, nearly 80 in *α Orionis*, and 15 in *β Pegasi* are given. In the spectrum of *Aldebaran*, coincidence with nine of the elementary bodies has been observed, *viz.* sodium, magnesium, hydrogen, calcium, iron, bismuth, tellurium, antimony, and mercury. In the spectrum of *α Orionis*, five cases of coincidence were found, *viz.* sodium, magnesium, calcium, iron, and bismuth. *β Pegasi* furnished a spectrum closely resembling that of *α Orionis* in appearance, but much weaker. It was particularly noticed that the lines C and F, corresponding to hydrogen, which are present in nearly all the stars, are wanting in these two stars. In the concluding portion of their paper, the authors apply the facts observed to an explanation of the colours of the stars. They consider that the difference of colour is to be sought in the difference of the constitution of the investing stellar atmospheres, which act by absorbing particular portions of the light emitted by the incandescent solid or liquid photosphere, the light of which in each case they suppose to be of the same quality originally, as it seems to be independent of the chemical nature of its constituents.

The subject of stellar and planetary spectra has been likewise continued by Father Secchi. Taking advantage of the moon being in the neighbourhood of Jupiter and Saturn, he has compared the spectra of the three, and has satisfactorily made out the presence of atmo-

* 'Phil. Mag.' August, 1864. † 'Phil. Mag.' July, 1854.

spheric lines in the spectra of the planets, and the absence of them in that of the moon. This observation appears to show that the so-called atmospheric lines are not, after all, due to the absorbing action of the earth's atmosphere, or they would be present in the lunar spectrum.

It is well known to all who have devoted attention to photographic chemistry that iodide of silver occurs in two modifications, one being sensitive, whilst the other is insensitive to the action of light. M. Kaiser, of Leipzig, has discovered that the insensitive modification may be transformed into the sensitive iodide by being submitted to the vapour of benzol. He says that the benzol vapour acts by developing ozone in the air, and he has found that an atmosphere ozonized by electricity has precisely the same action. M. Kaiser's experiments with benzol vapour seem to confirm a suspicion entertained by many photographers, that the wet collodion-plate is more sensitive than any other from its containing a small quantity of ozonized ether on its surface, and not because its pores are more open in the wet state than when dry.

Speaking of photography, we transfer the following extract from a note just received from Dr. H. Draper, of New York. He says, "I have succeeded in taking a photograph of the Moon 50 inches in diameter, a size hitherto unapproached, and, in fact, as large as present processes will permit. It required six weeks of steady work, but fully repays me in the imposing effect gained."

The subject of light in relation to chemistry will probably attract much more attention in future than it has hitherte done. Chemists have, however, somewhat neglected the absorption spectra given by metallic and organic solutions in their hunt after fixed lines. At one of the recent meetings of the Chemical Society,* Professor G. G. Stokes, Sec. R.S., favoured the members with a discourse on the detection and discrimination of organic bodies by means of their optical properties. The properties most available for the chemist were colour-production by absorption, fluorescence, and reflection, and in a limited number of instances the phenomena of circular polarization. The professor exhibited a very simple arrangement of apparatus for the purpose of observing the effects of absorption. It consists of a small glass prism, having a refracting angle of 60° mounted vertically at one end of a long wooden tube, the other end of which is closed, with the exception of a narrow slit regulated by a screw; and against the outside of this aperture, and in front of the lamp, a test-tube containing the solution to be examined can be supported by means of elastic bands. When a dilute solution of permanganate of potash is viewed through the prism, the spectrum appears furrowed out with five dark bands of absorption at regular intervals between the fixed lines D and F, and many other coloured liquids, organic and inorganic, exhibit characteristic absorption-bands, by means of which they are capable of identification. In proof of the value of this test to the detection of organic colouring-matters, Professor Stokes stated that Dr. Stenhouse had supplied him with a mixed colouring-matter, in which three of the madder principles were contained—*viz.* alizarin,

* 'Chemical News,' vol. x. p. 283.

purpurin, and rubiacin; and in a piece of the dry material no larger than a pin's head all three substances were distinctly recognized.

The poisonous nature of the green colouring-matters in general use has led to numberless attempts to substitute for them pigments of less danger. At the recent meeting of the Société Stanislas at Nancy, a proposition was made to employ the beautiful green manganate of barium as a pigment. Although very beautiful and comparatively inexpensive, this pigment would still labour under the disadvantage of being poisonous, whilst at the same time it is likely to be deficient in permanence.

Heat.—One of the most important investigations in this branch of science has recently been communicated by Dr. Kopp to the Royal Society. He has been engaged in the determination of the specific heat of an immense number of solid and liquid bodies, and has devised a very simple method of performing the experiment, thus bringing the determination of specific heat out of the restricted sphere of the physical cabinet, with its complicated apparatus, within reach of the ordinary appliances of the chemical laboratory. Dr. Kopp has arrived at the result that each element in the solid state, and at an adequate distance from its melting-point, has one specific or atomic heat; and that for each element it is to be assumed that it has essentially the same specific or atomic heat in the free state and in compounds. The author discusses the applicability of Dulong and Petit's law, and shows that it is not universally applicable. He concludes his memoir with some considerations on the nature of the chemical elements, and shows that chlorine, bromine, and iodine (which are even now regarded by some as peroxides of unknown elements), if compound at all, are not more so than the other elements to which Dulong and Petit's law is considered to apply. If this law were universally valid, it might be concluded that the so-called elements, if they are really compounds of unknown simpler substances, are compounds of the same order, and have the same degree of composition; but with the proof that this law is not universally true, the conclusion to which this result leads loses some of its authority. In a very great number of compounds, the atomic heat gives however, more or less accurately, a measure for the complication of the composition, and the conclusion appears legitimate that for the so-called elements the directly or indirectly determined atomic heats are a measure for the complication of their composition. Carbon and hydrogen, for example, "if not themselves actually simple bodies, are yet simpler compounds of unknown elements than are silicium or oxygen," and still more complex are the large number of elements which may be considered as following Dulong and Petit's law. With reference to the nature of the so-called elements, the author states that it must not be forgotten that his conclusions only give some sort of clue as to which of the present undecomposed bodies are of more complicated and which of simpler composition, but they tell nothing as to what the simpler substances are which are used in the construction of the compound atoms. But even if these conclusions are not free from uncertainty and imperfection, they are well worthy

of attention when they bear upon a subject so shrouded in darkness as the nature of the undecomposed bodies.

The passage of hydrogen gas through homogeneous bodies at a high temperature has lately attracted considerable attention on the Continent. Some time ago M. L. Cailletet communicated a note to the French Academy, in which he showed that hydrogen gas would pass through plates of wrought-iron several millimetres thick at a red heat. The author now shows that when the iron is cold, or at a temperature of only 210° C., hydrogen will not traverse a plate of only $\frac{1}{35}$th millimetre in thickness. M. H. Ste. Claire Deville has likewise been continuing his experiments on the same subject. His method of observing the phenomenon is to fill a wrought-iron tube with nitrogen, and place it in a porcelain tube, through which a current of hydrogen is passed. Upon heating the whole in a furnace, and observing the pressure on the inside and on the outside of the iron tube, it is found that that of the interior may become almost double that of the exterior, in consequence of the hydrogen permeating the walls of iron and adding its pressure to that of the nitrogen. Unless the temperature is very high, no nitrogen passes out; but at very exalted temperatures, the author remarked that the internal and external pressures became equalized, in consequence of the intra-molecular spaces becoming so much dilated as to allow the nitrogen to pass freely. M. Deville conceives that if we knew the law of the dilatation of these inter-molecular spaces, we might determine the relative sizes of the molecules of hydrogen and nitrogen.

The same indefatigable experimentalist has been also engaged with M. Troost in perfecting the means of determining high temperatures, and they describe a porcelain apparatus by which they measure a temperature reaching as high as 1530° C. The description is too long to be given here, but the account leaves no doubt that we have now a pyrometer capable of giving very exact indications, and likely to receive important applications. The authors record that, at the temperature above given, copper and silver seemed to be vaporized, and feldspar was fused to a perfectly clear glass. An iron nail, however, showed no signs of fusion.

It has often been observed that a diminution of density occurs when certain minerals are exposed to heat, and, in particular, it was announced by Magnus some years ago, that specimens of idocrase after fusion had diminished considerably in density without undergoing any change of composition. Dr. Phipson has recently repeated this experiment of Magnus, and finds that it is true both for the whole family of garnets as well as for the minerals of the idocrase group. He finds that it is not necessary to melt the minerals, the change of density occurs upon their merely being heated to redness without fusion; and Dr. Phipson has obtained the curious result, that the diminished density thus produced by the action of a red heat is not permanent, but that the specimens in the course of a month or less resume their original specific gravities. Thus three specimens of lime-garnet mellitite from Vesuvius, having an original density respectively of 3·345, 3·350, and 3·349, after being heated to redness for a quarter

of an hour and allowed to cool, were found to have their specific gravities diminished respectively to 2·978, 2·980, and 2·977. In one month's time the specific gravities, upon being again determined, were found to have risen to 3·344, 3·350, and 3·345. The author considers it probable that this property will be found to belong more or less to all substances without exception.

It has become an important desideratum for physicists engaged in the investigation of the spectrum lines to be in possession of an instrument which will readily reveal the presence of fixed lines in the heat-spectrum. The ordinary form of thermo-electric battery is inapplicable for this purpose on account of its shape, besides being scarcely delicate enough for rays of feeble intensity. Mr. Crookes has proposed a method of forming a thermo-spectrometer, which will enable physicists to examine and map out the thermal lines of the spectrum as accurately as this can be done with the visible and photographic portion. Instead of using antimony and bismuth bars, it is proposed to use the far more powerful combination of antimony and tellurium. A single row of these bars are soldered together at their alternate ends, and, after being cemented to a temporary but rigid flat surface, the series is ground perfectly flat. This flat side is then cemented to a permanent support of glass, porcelain, ebonite, or other suitable non-conducting material, and the other side (after removal of the temporary supporting-surface) is likewise ground down until the series of bars is no thicker than a card. This side is now cemented to the same kind of supporting material as was used for the other side, and the whole is firmly and securely sealed up, so as to leave only the ends exposed. The end of the pile now appears in the form of a very narrow, slightly-disconnected line, half-an-inch or so in length, and consisting of the extremities of ten or a dozen couples of antimony and tellurium bars, each not larger than a pin. By connecting the extremities of this pile with a sensitive galvanometer, and carrying it along the ultra-red end of the spectrum, keeping the line of extremities parallel with the fixed spectrum lines, it will instantly reveal when a ray of heat shines upon it by a deflection of the needle; and the comparative intensities of the thermic rays can be at the same time ascertained by recording the angular distance to which the needle is deflected.

Electricity.—Although not able to record any striking discovery in electrical science which has taken place during the last quarter, we have noted several ingenious applications of this force, as well as improvements in instruments connected with it. A suggestion of M. Dufour for preventing the explosion of steam-boilers is especially worthy of notice for its ingenuity, as well as for the important results which would attend its successful adoption. Mr. Grove has shown that when water is deprived of the air naturally dissolved in it, and is then heated, it does not boil steadily at any fixed temperature; the temperature rises many degrees above the normal boiling-point, and the liquid then suddenly bursts into tumultuous ebullition; it now remains quiet for a short time whilst the temperature is again accumulating, and the same phenomena are again repeated, increasing in violence

until the water is projected into the air with an explosion, the vessel being frequently broken. It is to occurrences of this kind that boiler-explosions are supposed to be most frequently due, and it is the general opinion that if the water could be kept supplied with air, ebullition would take place with perfect regularity. The difficulty has been how to effect this necessary aëration, and M. Dufour now proposes to accomplish it by carrying an insulated platinum-wire into the water, and connecting the wire and the boiler with the opposite poles of a battery. It is imagined that the decomposition of the water will keep it well supplied with gaseous material, and will prevent the ebullition from becoming explosive.

An ingenious modification of the ordinary electrophorus has been devised by Messrs. Cornelius and Baker, of the Franklin Institute, for lighting gas. It consists of a spherical cup of brass lined with sheep-skin and silk, into which drops a corresponding hemisphere of hard india-rubber. The brass cup communicates with a wire near the jet. To light the gas, the hard-rubber hemisphere is raised by means of a little handle, and the spark passes, lighting the gas in its passage. They have also devised a portable electrophorus of tubular construction; it consists of two brass tubes, united together by a ring of hard india-rubber, closed at each end, and covered internally with a silk padding. Inside the tubes is a cylinder of hard rubber, which passes freely down the tubes when they are reversed. The apparatus is grasped by the non-conducting ring and held upright, the hard-rubber cylinder being at the lower end. Upon reversal it passes to the other end, charging the brass tube in its passage.

Father Secchi advises the use of fine sand or of powdered sulphur in the porous cell of the Daniel's battery, in order to increase its constancy. He accounts for its action by supposing that when the ordinary liquid alone is used, there is greater liability to local action taking place upon the zinc. In a battery, the circuit of which is closed for two minutes every quarter of an hour, the learned father has used an ordinary piece of commercial sheet-zinc half-a-millimetre in thickness, which has continued in action for more than six months without showing the least sign of local corrosion.

Our enterprising French neighbours, always before us in luxurious applications of science, are rapidly applying the electric light to the illumination of private and public assemblies. It has for some time past been introduced at the Tuileries on the nights of the grand balls, and the Abbé Moigno has lately made use of it during his lectures on the progress of science in the hall of the Société d'Encouragement. Instead of being illuminated by the innumerable jets of gas with which the hall is provided, a single electric light placed in a central position lit the room in the most perfect manner. The consequence was that, although the lecture was delivered during the height of the hot season in Paris, the room was kept comparatively cool.

The celebrated electrical instrument maker, Rhumkorff, has deservedly been presented with the Napoleon III. prize of 50,000 francs for the induction apparatus that bears his name. The King of Hanover has also sent him a large gold medal.

IX. ZOOLOGY AND ANIMAL PHYSIOLOGY.

It is stated that researches have been recently carried on in Borneo, on the most extensive scale, with a view to solve the oft-disputed question of the plurality of species amongst the orang-outangs of that island, and that Dr. E. P. Houghton is about to submit a very large collection of skulls of the different varieties or species to English zoologists.

The Aye-aye (*Cheiromys Madagascariensis*), an anomalous creature, which has lately attracted more attention from the fact of a living specimen being successfully brought to the Zoological Gardens, has formed the subject of a memoir by Dr. Peters, before the Berlin Academy. It had been shown by Professor Owen to be allied to the Lemurs, while the structure of the incisors shows an important relation to the Rodents. Dr. Peters concludes that, if we are not prepared to make a separate order for this genus, to be placed intermediate between the quadrumana and the rodents, as Brandt has proposed, it would, on the whole, be the most natural to regard it as an aberrant division of the Lemurs, and to unite it with them to form the representatives of a particular family. With the exception of the disposition of the hands and the opposable thumb of the hinder extremity, the principal character to be considered is the formation of the skull and brain. As regards the dentition, it would be of much interest to investigate whether at any period of the fœtal life of the glires there exist teeth corresponding to the milk-teeth of the aye-aye, the formula of which exhibits a close relation to that of the insectivora.

The sudden occurrence of Pallas' sand grouse (*Syrrhaptes paradoxus*) over the greater part of Europe has attracted the attention of ornithologists, and Mr. Alfred Newton has collected information which shows that this remarkable bird, hitherto almost unknown to the European fauna, has been met with during the year 1863 in no less than 148 localities in Europe and Great Britain, tracing the invading host through 33° of longitude from Galicia to Donegal. He regards the proximate cause of this wonderful movement to the natural overflow of the population of *Syrrhaptes*, resulting from its ordinary increase, being a bird which has comparatively few enemies, while its time of incubation is short in comparison with what it is in most ground-breeding birds. Mr. Newton inclines, from the remarkable form of the primaries of the wing, the filiform tail feathers, and syndactylous feet, to believe that the sand grouse is not improbably "the conquering hero of a long struggle for existence," and striving to extend its range in all directions; and he predicts that unless some physical change occurs in the Tartar steppes which may have the effect of relieving the internal pressure, another outpouring may be safely predicted.

Mr. Allis exhibited to the Linnean Society bones and photographs of a Dinornis, of which the skeleton is nearly perfect. Out of nine left ribs seven are still *in situ*, and the sternum is perfect and as fresh to appearance as though the bird had been alive last year. The inner

left toe has the whole of the outer sole still adhering to it, as well as part of the sole of the foot. On the lower part of the back is still a considerable portion of the outer skin studded with the quill part of the feathers, and in one or two rare instances portions of the web of the feather. The bones of the neck still show greater or less marks of having been within reach of the destructive effects of the atmosphere, while the head at one extremity, and the first dorsal vertebra at the other, are each as perfect as though they had been taken from a fresh killed bird by the most skilful anatomist. Mr. Gibson, a resident in New Zealand, sent it to his brother, Dr. Gibson, of York, with a statement that it was discovered in a sand-hill, sitting on its eggs, by some diggers, about 100 miles up the country from Dunedin, to which place it was sent for sale. When the boxes were opened they were thought to contain only the bones of one adult bird, but an examination showed a number of small bones belonging to very young birds, its brood, consisting of five individuals. Dr. Hooker suggested that the perfect condition and high preservation of the bones might be due to ice; but Professor Huxley and others took a different view of the subject, and thought that the bird in question had probably been living within ten years. When we remember that in the Great Sahara the ostrich is only to be discovered at an immense distance, although there are no intervening objects behind which he could shelter, the moa, if possessed of half the subtlety of the ostrich, might escape for years the notice of the few Europeans who have ventured to intrude on his haunts, and it is by no means impossible that this gigantic bird may exist to this day undiscovered. Explorations of the middle island are being made by Dr. Haast which promise soon to settle this interesting question.

The great interest attending the discovery of remains of animals recently extinct, or concerning whose present existence zoologists are in great doubt, has led Mr. Alfred Newton to follow up the researches of the late Mr. John Wolley upon the great Auk, or Gare fowl (*Alca impennis*), which he has done so successfully as to have secured from Funk or Penguin Island, 170 miles north of St. John's, Newfoundland, a natural mummy of that curious bird, which vies with the dodo in ornithological interest. Although numerous skins of the bird exist in various museums of Europe, the osteology was very imperfectly known, and the present mummy is, with one exception, the only approach to a complete skeleton existing in Europe. Mr. Newton has placed it in the hands of Professor Owen, from whom no doubt we shall receive an elaborate monograph upon the subject.

Mr. William Bennett gives an account of his attempts at breeding Emeus (*Dromius*) in Surrey, which throw some light upon the economy of struthious birds. In 1863 the female continued laying until she had deposited twenty-eight eggs, weighing about forty pounds. The male bird was set upon fourteen of these, and the remainder placed in an incubator. For a month all went on well, but in the fifth week the birds were so greatly excited by the appearance of a boat, that the eggs were left. Those in the incubator all failed also, although the chicks had nearly reached maturity. A new lot of eggs began to be deposited on December 23rd, and on February 14th (of the present year) the

male commenced sitting on ten eggs. After eight weeks, signs of life appeared in the eggs, and on April 13th the first was hatched, and ultimately ten young emeus repaid Mr. Bennett's care and labour. The normal period of incubation thus appears to be about sixty days, but although the number of eggs laid is large, few appear to be hatched in the wild state, as the eggs are laid in various sheltered places, and are afterwards collected by the male, that is, as many as he may happen to find. The female takes no part in incubation.

A series of experiments has been made by M. Barthélemy on monstrosities, both artificial and natural, among lepidopterous insects. He performed his experiments chiefly on the chrysalis, and endeavoured to cause modifications similar to those obtained by covering the eggs of birds with varnish. On covering the chrysalis with oil it was found that it died before completing the metamorphosis; but on covering either the thoracic or abnormal portion with wax, a retardation of development was perceived, which was much greater in the case of the thoracic parts. The cephalic part of the nervous system was much retarded in development, but the other parts of the ganglionic chain appeared to be developed as usual. He succeeded also in suppressing the development of the generative organs.

Mr. Bates has added another remarkable example of mimetic resemblance, in a spider, of the genus Salticus, to a flower of Senecio pubigerus (Linn.), a common roadside weed in dry ground about Cape Town. It was noticed by Mr. Roland Trimen, of Cape Town, who says:—

"Leptoneura Clytus, a handsome butterfly of the Satyrus family, is very abundant just now. Flowers are rather scarce at this season, and a tall straggling plant with yellow composite flowers attracts these butterflies with many other insects. As I approached a plant upon which were several Leptoneuræ, I observed that two specimens did not fly off with the others, and found that each was in the clutches of a bright yellow spider. I removed one of these butterflies, and as the spider shrunk up its limbs on the flower, which equals it in size, it was scarcely distinguishable, so exactly similar was it in colour. Recovering from its alarm, it slowly moved to the side of the flower, and holding on to the stalk by its two hindmost pairs of legs, it extended the two front pairs upwards and laterally. In this position it was scarcely possible to believe that it was not a flower seen in profile, the rounded abdomen representing the central mass of florets, and the extended legs the florets of the ray; while to complete the illusion, the front femora appressed to the thorax have each a longitudinal red stripe, representing the ferruginous stripe on the sepals of the flower. As the other spider also assumed the same attitude when robbed of his butterfly, and as both retained it for a considerable time, I conclude it is their ordinary mode of waiting for their prey."

M. Matteucci brought before the French Academy a remarkable case, in which a number of eggs, after having been allowed to remain under the hen for different periods, were left to putrify. In no case did he find the slightest trace of either animal or vegetable life upon breaking the shell of the putrified eggs. He considered that as long as the shell remained intact no germs could by any means obtain admission, and therefore the circumstances of this case were peculiarly

favourable for experiment as to the possibility of spontaneous generation. M. Milne-Edwards, however, stated that M. Panceri had shown that the shell is not always impervious to the passage of organized bodies.

The subject of spontaneous generation is still occupying considerable attention both in France and England. Messrs. Pouchet, Joly, and Musset are endeavouring to prove by their experiments that the air does not normally contain the incalculable number of ova and spores ascribed to it by M. Pasteur. That shown, they engage to prove that with a boiled fermentable substance to be left to their choice, organized productions shall be constantly and universally obtained in vessels hermetically sealed, and containing a cubic decimeter of atmospheric air. The statement of M. Pasteur, on the other hand, is, that it is possible to obtain in a given place a sufficient but limited quantity of atmospheric air, having undergone no kind of physical or chemical alteration, capable, nevertheless, of causing an alteration in an eminently putrescible liquid.

Dr. Child, of Oxford, has laid some experiments before the Royal Society, made during the summer of 1863, in which milk or fragments of meat and water were placed in bulbs of glass 2½ inches in diameter —some of the bulbs being filled with air previously passed through a porcelain tube containing fragments of pumice-stone, and heated to vivid redness in a furnace; while others were filled respectively with carbonic acid, hydrogen, oxygen, and nitrogen gases. Some of the substances were boiled from five to twenty minutes, in all cases in the bulb, and with the stream of gas or air still passing through. The microscopic examination of the contents took place at various times from three to four months after their enclosure. When the substances had not been boiled, in every case but one, low organisms were found; and when the substances were boiled the results were:—in the carbonic acid and hydrogen experiments, no sign of life; in the heated air and oxygen experiments, organisms were found; and also in the nitrogen experiments where meat was used, but none where milk was used. It is worthy of remark that in these experiments organisms were found under the precise circumstances in which M. Pasteur states that they cannot and do not exist.

M. Coste has laid before the French Academy some important observations on the development of ciliated Infusoria, which in many points oppose the doctrines of M. Pouchet. Infusoria, he affirms, make their appearance in an infusion long before the pellicle, falsely called *stroma*, a name which attributes a function to it that it does not possess. They are introduced either as eggs or cysts with the hay, moss, or leaves of which the infusion is made. Although the *stroma* is produced in infusions made with substances which are not exposed to the air, such as the pulp of the apple, infusoria are never found in such infusions if the vessel be covered with a piece of glass. Nevertheless, if, after ten or twenty days, no infusorium be visible, and two or three Kolpods, or Chilodons, or Glaucomas be introduced, these species will soon show themselves in prodigious numbers, in consequence of their mode of immediate multiplication by division. Some,

as the Glaucomas, Chilodons, and Paramecia, divide themselves without encysting; others, like the Kolpods, encyst themselves before division. After multiplying by division in the interior of their cyst, the Kolpods encyst themselves again, and remain in that state until the infusion is completely dried up, and they return to life only after a fresh moistening. Filters, however, allow small infusoria, such as Kolpods, Chilodons, &c., their cysts and eggs, to pass through them.

X. SCIENCE IN THE PROVINCES.

The numerous provincial Societies, not behindhand in advancing the cause of scientific progress to which they have allied themselves, exhibit an amount of activity worthy of the cause, and which shows itself from time to time in the publication of Proceedings which are often of great interest and value. Many of these have forwarded to us an account of their labours, and it affords us great pleasure to lay before our readers a brief summary, as evinced by these published results. Those who disparage everything provincial, cannot fail to observe that the Metropolis stands foremost solely because there is concentrated, as in a focus, the chief talent of the country; and that, therefore, there can be no reason to despise the lucubrations of Societies which include the names of Joshua Alder, Rev. A. M. Norman, Albany Hancock, Rev. L. Jenyns, W. Pengelly, C. Spence Bate, and many others.

Among such provincial Societies, the 'Tyneside Naturalists' Field Club' occupies a prominent position, and periodically publishes Transactions which are full of interest. The latest number is a worthy successor to many others. Among the chief objects of this Society is the publication of catalogues of the natural productions of Northumberland and Durham, and from time to time the Coleoptera by Messrs. Hardy and Bold, the Mollusca by Mr. Alder, the Zoophytes by the same, the Permian Fossils by R. Howse, the Lepidoptera by G. Wailes, and Marine Algæ by G. S. Brady, have appeared; while the freshwater Algæ, Foraminifera, Echinodermata, Annelida, Crustacea, Hymenoptera, Hemiptera, Birds, and fossil Fish are in progress. The present number contains a most interesting "catalogue" of the Mammalia, by Messrs. Mennell and Perkins, occupying about sixty-five pages, and abounding in information both technical and popular. It is a model of what such Fauna lists should be, and we wish that every county of our island had so excellent a chance of being thoroughly examined and elucidated as have those of Northumberland and Durham. Fifty out of the sixty-seven wild British species are claimed for those two counties.

Mr. G. S. Brady, whose attention is directed to the Entomostraca, has added several of these organisms to the British lists, by the discovery of three species of Cypris and two of Candona in the above counties, which are here described and figured. One of these, Cypris affinis, was known as an inhabitant of the Continent, but has recently

been taken in both the northern counties; and another species found there is of great interest, inasmuch as it was first described as a tertiary specimen by Rupert Jones, but has since been discovered in brackish water at Gravesend, and at Warkworth.

The British Association, at its Cambridge meeting, renewed a grant for dredging the Dogger Bank, and the coasts of Northumberland and Durham. These explorations have resulted in several interesting and new forms, including a beautiful nudibranchiate mollusk (*Hero formosa*, Lovèn), which occurs on the coasts of Norway and Sweden. The Durham coast, however, is described as generally poor in Mollusca, which have a boreal type, approaching more nearly to the Scandinavian than to the South of England fauna. Mr. Alder gives a report upon these, while Rev. A. M. Norman reports upon the Crustacea, which includes specimens of Sacculina and Peltogaster, rare forms which are found parasitic upon the abdomen of various stalk-eyed Crustacea. The Echinodermata yielded a rich return, including a new species (*Ophiura squamosa*, Lütken), and Mr. Alder describes among the collection of Zoophytes a new Scrupocellaria (*Delilii*), and other remarkable forms.

In further proof of what we have observed concerning the working of this provincial Society, we must also refer to Mr. Hodge's list of the British Pycnogons (Araneoid crustacea), in which thirty-two species are included, ten of which are new. These are described and figured by the author.

'The Woolhope Naturalists' Field Club' principally employs itself with the Natural History of Herefordshire; and the fifth number of its Transactions is chiefly occupied with an elaborate and exhaustive treatise on the 'Mistletoe in Herefordshire,' by Dr. Bull. This paper contains a great amount of information concerning this interesting parasite—the mode of its propagation and growth—the trees it lives upon in this country—the recorded history of its growth on the oak in England—and the romance of its history as developed in times past and present. Thirty trees are mentioned as bearing mistletoe, including apple, seven species of poplar, hawthorn, crab, lime, maple, acacia, flowering-ash, willow, hazel, alder, sycamore, elm, horse-chestnut, &c.; but the favourite site of the mistletoe is certainly the *apple-tree*. The actual numbers were 784 trees with mistletoe, and 1,218 without it—or from other sources, a general average of 34 per cent. Mistletoe is never seen to grow spontaneously upon the beech, birch, bird cherry, wild cherry, sloe, hornbeam, elder, holly, dogwood, box, Lombardy poplar, sweet-chestnut, walnut, laurel, nor on any other of the many introduced varieties of trees and evergreens. Only six well-authenticated instances are recorded of its growing upon the *oak*, throughout England, although others have been noticed which were either erroneous or have now ceased to exist.

'The Devonshire Association for the Advancement of Science, Literature, and Art,' held its third Annual Meeting in July at Torquay, under the presidency of Mr. Vivian, and after an inaugural address, several papers of considerable interest were read, among which were:—

Mr. Hearder, of Plymouth, 'On the Preservation of the Iron-plating of Wooden Ships from the Corrosive Action of Sea-water.' It having been found that large holes had been made in a new 5-inch plating, he proposed to place gutta-percha or india-rubber between the iron and the copper-sheathing, and, if necessary, a band of zinc also on the inside of the plating, to prevent even the possibility of communication with the copper.

Mr. Spence Bate described a kitchen-midden recently found in the north-east of Cornwall, an ancient Cornish barrow, and a Romano-British burying-ground. The midden was accidentally discovered in Constantine Bay, and consisted of limpet, mussel, and whelk shells, bits of greenstone probably used as hammers, and flint, bones of the red-deer, ox, sheep, and lamb, pieces of pottery, &c. The midden, he believed, indicated the site of a very extensive village of pre-historic man. Near the midden was found a barrow, or circular mound, 100 feet in diameter. Within it, in a cavity covered by a stone, had been found an earthenware vase containing human bones partly burnt. The burial-ground was discovered in making the excavations from Fort Stamford, near Plymouth. Underneath blocks of limestone had been found bones, pottery, bronze armlets, fibulæ, mirrors, a small dagger, and pieces of partly-decomposed iron, finger-rings, scissors, &c.

Visits to Brixham Caves and Berry Head gave Mr. Pengelly an opportunity of calling attention to extraordinary geological phenomena. The Devonian limestone is traversed by two systems of joints, one north and south, and the other east and west. Some of these are occupied by dykes of fine triassic sandstone. A careful study of these rocks proves that an almost incalculable period must have elapsed since the joints first opened, for there is—1st. The filling in of the east and west open joints with red sand, at a period not earlier than, if so early as, the commencement of the Torbay trias. 2nd. The induration of the sand with coherent and durable dykes capable of being fissured and faulted without their sides falling in. 3rd. The formation of longitudinal fissures in dykes. 4th. The gradual filling of these fissures, not with sand, but by the precipitation of carbonate of lime. 5th. The formation of transverse joints passing in a north and south direction alike through the triassic dykes and veins, and the pre-triassic rocks. 6th. The faulting of the entire mass—rocks, dykes, and veins—by inequalities of movement in an approximately horizontal direction; and 7th. The filling in of the north and south open joints with red sand as in the first instance, so as to form dykes, passing through those previously existing, the two systems being distinguished by well-defined walls, and a marked difference in colours. The triassic rocks, it should be remembered, in making calculations of time, are a mere sub-division—and that the lowest—of the mesozoic group. These facts appear to Mr. Pengelly to show conclusively that the rocks in which they occur, are the exponents of a lapse of ages great beyond human conception. This interesting paper has been separately published by Mr. Pengelly with illustrative figures.

The 'Torquay Natural History Society,' of which Mr. Pengelly

is president, has also had the advantage of an admirable address from that gentleman; in which he ably reviewed the events of the past year, naturally dwelling upon those geological discoveries which have caused so much discussion in relation to the disputed antiquity of man, and gave a well-digested summary of the evidence afforded by the discovery of the shell-mounds of Denmark, the lake dwellings of Switzerland, the elephant remains at Saint Prest, near Chartres, and the quaternary gravels of the Somme. Nor did the questions of Anthropology meet with less than their share of criticism; and the opinions of Waitz, Huxley, and others, received considerable attention. Professor Max Müller's view of the original unity of all existing languages, and Mr. Crawfurd's counter-view, were also set forth, with a strongly expressed opinion against the former. The whole address forms an excellent and philosophic summary of these leading scientific topics of the day from the pen of one well able to deal with them, and to express an independent opinion.

'The Plymouth Institution and Devon and Cornwall Natural History Society,' is another active body in the West of England, one of whose objects is, like the 'Tyneside Club,' the cataloguing of the natural productions of those counties. The last published number of their Transactions contains lists of the mammals, birds, reptiles, amphibia and lepidopterous insects of Devon, which cannot fail to be of service in elucidating the general natural history and distribution of animals in these islands. It is also enriched with a paper by Mr. Pengelly, on the Red Sandstone, Conglomerates, and Marls of Devonshire.

Other Western Societies which are keeping up the lamp of science with assiduity, are the 'Bristol Naturalists' Society,' whose monthly Proceedings find a place in the 'British Daily Post'; and the 'Bath Natural History and Antiquarian Field Club,' whose president is the Rev. Leonard Jenyns. An admirable address from this venerable naturalist to the club now lies before us, but our space will only allow us to thus briefly refer to it.

In the Eastern district and near London, the 'West Kent Natural History, Microscopical, and Photographic Society,' which has absorbed the 'Greenwich Field Naturalists' Club,' and is supported by many leading scientific men of London, whose residence outside the metropolis enables them thus to meet periodically on Blackheath, for the prosecution of their favourite pursuits. Of this club the excellent Linnæan Secretary, Mr. Currey, is president, and a most interesting address from him, on the progress of science, has been circulated.

Among naturalists' field clubs, however, none have met with so surprising success as that at Liverpool. This club was established at Liverpool in 1860, the year following the foundation of a similar club at Manchester; but the former has outstepped the latter, and its steadily increasing number of members has now reached about 700. There can be no question that this club has done much to disseminate a taste for and knowledge of natural history, more especially of botany, in Liverpool. During the winter months periodical meetings are held, at which lectures are delivered and specimens exhibited, in which the

aid of the microscope is largely used; and in summer, excursions to a greater or lesser distance into the country are taken, at average intervals of three weeks, on which occasion prizes are offered, which are calculated to stimulate the taste for botanical pursuits. These prizes consist of books of the value of half-a-guinea, of which several are offered at each excursion, *viz.* for the collection, naming, and arrangement in natural orders of the largest number of species in flower; for the largest illustration of some given natural order; and for the simple collection of the largest number of species in flower. In addition to these, numerous prizes are offered for collections to be made during the year, which have met with the most encouraging success. Nor should it be omitted to be mentioned, that twice has this club held high festival in the magnificent St. George's Hall, on which occasions extraordinary exhibitions of the most varied and most valuable natural objects have been made, and certainly forming the most remarkable natural history festivals which it has ever been our lot to witness.

The 'Cambridge University Natural Science Society,' which has sprung from a University Club, is a new Society, and if we may judge from the earnest spirit of the address of its President, Mr. C. W. Villiers Bradford, it is one which is destined to do considerable service. The subject of the position of Natural Science in the University curriculum, and the encouragement given to its prosecution, is brought forward in a prominent manner. The Natural Science Tripos standard was raised in 1861, so that a first class in that Tripos was equivalent to the position of a Wrangler. The numbers availing themselves of the Tripos, however, have been very small, owing to the little encouragement offered by the University and Colleges. Out of twenty-two University prizes, not one is devoted to any department of Natural Science; and out of the seventeen colleges which compose this commonwealth of learning, only *three* offer any pecuniary inducement to scientific study, *viz.* Caius, Sidney Sussex, and Downing Colleges; while no college has ever yet given a fellowship for Natural Science alone. At Oxford this, however, is the case, and members of both Universities are allowed to compete. So long, therefere, as the colleges of Cambridge refuse to extend to science that stimulus to energetic work which every other branch of study possesses, we may predicate for the Natural Science school but a struggle for existence there. Few men who go to a University can afford to spend their school and college days in competing for an empty honour, while the same time and labour differently bestowed may ensure a provision for the early years of a profession; but when Fellowships are given equally for science, mathematics, and classics, possibly even a greater competition may be expected in the former case than in the two latter, and perhaps the Fellows of colleges foresee this. The University prizes are restricted in their object; the Scholarships also are but partially free from similar trammels, but the Fellowships are entirely in the hands of the Masters and Fellows of colleges. But, although the colleges show so little favour to science, there are six Professors of high reputation, and also well-stocked geological,

mineralogical, and anatomical museums, numerous laboratories, a magnificent collection of scientific books in the University Library, and an excellent botanic garden; but the Professors require assistants, and the collections require curators. We sympathize with the Cambridge University Natural Science Society in its attempts to arouse the University to a sense of its shortcomings, which place it in the rear of other similar noble educational establishments; and we hope that, ere long, the attention which is thus called to these wants may fulfil the object which they have in view, and that their laudable endeavours may be crowned with complete success.

XI. SCIENCE IN ASIA.

GREAT were the advantages conferred on science by the foundation of the Asiatic Society of Bengal. It has given a start to much scientific investigation, and seems to promise much in the future. It is on the point of conferring an immense benefit on society at large in Calcutta by placing its extensive Museum in the hands of the Government, while it gives valuable assistance to individual collectors by forming a means of communication between zoologists in all parts of India. This last object it is intended to carry out according to a plan proposed by Mr. C. Horne, by means of lists of all naturalists, numismatists, and others who wish to enrol themselves as desirous of exchanging their duplicate specimens. It is not intended to confine these lists to members of the Society, but to admit all who are willing to join. Other scientific bodies are coming into existence, amongst which we may mention the Dalhousie Institute, which has had a site afforded it by the Government, on which a suitable building is to be erected as soon as an opportunity is offered for the Governor-General to lay the foundation stone. At Allahabad, moreover, a museum and a library are on the point of being established. A circular has been issued by Dr. Cunningham, the curator and secretary of the future institution, to all the Government officials to collect materials under the six following classes:—

A. Specimens illustrative of antiquity, such as old coins, MSS., arms, &c.
B. Raw materials.
C. Agricultural produce. (Is this not included under the preceding head?)
D. Manufactured goods.
E. Specimens illustrative of natural history.
F. Models of machinery.

To the library the curator hopes to attract the legacies of officers and Government servants departing for Europe, expectations that probably may be realized if we consider the enormous expense of carriage which would be incurred in bringing home books. A site has not as yet been

assigned, but it is probable that the Government will shortly provide one.

Hindû ignorance is an obstacle to many investigations. We cannot but rejoice to see so many native contributors to the proceedings of the Asiatic Society, and hope that much enlightenment may gradually spread amid all classes. Old religious prejudices are breaking down; the Suttee has disappeared. It appears that Juggernaut does not so readily procure victims as formerly, and it is actually proposed to check the possibility of this sacrifice of human life. But further than this, female education is gradually engaging the serious and earnest attention of the liberal-minded and influential circles of the Hindû community of Bengal. A Hindû gentleman, Baboo Gunja Gopal Chatterjee, has opened an entirely free school for girls on the western bank of the Hooghly. About forty attend, many of Brahminical caste. In the Madras presidency a more extensive movement has taken place—nothing short of a complete reformation—including the endeavour to promote female education, to discourage polygamy, and to encourage the re-marriage of widows. The religious views of the promoters of this movement are monotheistic, and all sectarian tendencies are discarded. But as a set-off against these advances in the way of education, we must record an instance of extreme bigotry on the part of some Mahometans in this same presidency. Two officers who attempted to visit the famous tombs of Golconda were vigorously abused and then pelted. From this attack of three or four hundred men they effectually defended themselves with whips, but when their assailants had been reinforced by some hundreds of villagers they seriously maltreated the officers, who escaped violence indeed, but who had to return without visiting the tombs.

The 'Journal of the Asiatic Society of Bengal' for the present year opens with a paper on "The History of the Burmah Race," by the Chief Commissioner of British Burmah, Lieutenant-Colonel A. P. Phayre, C.B. This gentleman has collected his information from a copy of the chronicles of the Kings of Burmah, entitled 'Maha Radza Weng,' presented to him by the reigning monarch, a man of some learning, who has caused a new edition of these annals to be compiled under his own immediate direction.

The conclusions arrived at by Lieutenant-Colonel Phayre from these accounts are in the main in agreement with the theory of Prichard, displayed in his 'Natural History of Man,' *viz.* that the Burmese race, in common with the peoples to the north and west of them, have descended from the high land of central Asia by the courses of the great rivers, and have thus overspread the low lands. Three tribes, the Burmese, the Karens, and the Mon, seem to have found their way southward along the courses of the Salween and Meenam; the first and last of these reached at an early period the upper part of the valley of the Irrawaddy; the Karens remained till of late in the mountains, but have now penetrated into the same valley, and have pushed onwards along the mountains of the sea coast. The traditions of migrations from India are supposed to have been invented after their conversion to Budhism by missionaries from Gangetic India,

for the purpose of connecting their own royal family with those of the reigning Budhist families in India. This conversion seems to have taken place whilst the capital was at Tagoung, since a Budhist image was discovered there inscribed with a well-known religious text in Deva-nagri characters, which bear a close resemblance to similar inscriptions at Allahabad. Now the Burmese and Tapaing writing of the present day is undoubtedly derived from the Deva-nagri character, but it also bears upon the surface of it a distinct impress of the Tamulic letters. We may well argue, therefore, that these few inscriptions were the work of the earlier Budhists that came from India, and who seem to have settled at Tagoung but a short time before it was overrun by the Tatar or Chinese race, whom the Burmese call Ta-ret or Ta-rook. The real origin of the race, then, was in the interior of the continent, but their traditions, founded on religious prejudices, point to an Indian birthplace.

In these days, when pisciculture is becoming attractive both to the man of science and even to the economist, the remarks of Mr. E. O'Reilly, the Deputy-Commissioner of Bassein, on the immense profits made from the fishing in the Lake of Clear Water in the district of Bassein, in Burmah, will be read with great interest. The lake to which these remarks refer is of a peculiar character, having but one stream which flows into it when the Irrawaddy, and in consequence the Bassein and its dependant, the Dugga, are swollen, and out of it when these rivers shrink again to their accustomed channels. The lake thus forms a natural preserve, and from its ring-shape it affords peculiar facilities for dragging. When the lake is at its lowest a fixed weir is built on one side of the outlet, and a drag-net, made of reeds, grass, and jungle-creepers, about 1,800 cubits long, is made on the other. This latter is moved gradually forward at the rate of about forty-five fathoms a-day for three months, until it is brought nearly opposite to the village on the shore of the lake, at a distance from its mouth. A bamboo weir is then erected to prevent the return of the fish, and the drag-net is taken to pieces and reconstructed by the first-mentioned weir, and then again dragged back in a contrary direction until it approaches the village on the other side. The fish are thus left cooped up until the first showers of the monsoon have cooled the water and the atmosphere, and then at the full moon in June the merchants assemble from Prome, Ava, and the other large towns on the Irrawaddy to attend the actual haul. Upwards of forty tons of fish are annually disposed of to these visitors, some in the form of dried fish, but also a large quantity is bought by the dealers from the lower parts of the river alive, and this is by them transported in bamboo cages kept under water. In the whole province of Pegu it is calculated that upwards of 1,800 tons of fresh-water fish are used by the natives, affording a very large source of revenue to the Government.

The condition of the dependency of Bustar, according to the report of Captain C. Glasfurd, Deputy-Commissioner of the Upper Godavery District, does not hold out any great enticement to the archæologist. The present, as well as the late dynasties of rajahs, seem to have had but little taste or liking for architecture; but about five

hundred years ago there reigned in Barsoor a family of rulers who have left several monuments of their power, though the neglect of later times has suffered these to fall into almost total decay. These ruins are enclosed by a wall forming a square of about a mile. Within this are the remains of four or five temples—massive, handsome, and richly sculptured. They are built of huge blocks of gneiss, put together without mortar. They owe their destruction principally to the insinuation of the roots of the *Ficus Indica*. A slab of stone was found inscribed with Sanskrit and Teloogoo characters, the latter so antiquated that they have not as yet been deciphered. A large tank in good repair was found near at hand, and about 150 tanks have been reckoned within a circuit of fifteen miles. A similar enclosure with temples was found at Duntewara, on the western bank of the Dunkunee; but at Madhota, one of the ancient capitals of the district, no ruins beyond mud walls were to be found.

The hot springs of India, not including petroleum wells, have been enumerated by Robert de Schlagintweit, Esq. They amount to ninety-nine in number. The hottest (202° Fahr.) is at Manikárn, in Kúlu, amongst the Himalayan provinces, and is 5,587 feet above the sea-level. The highest is at Momái, in Sikkim, in the same locality, and is about 16,000 feet high; the heat is 110° Fahr.

The original papers end with a memorandum on some ancient tiles found at Pugan, which have Budhist figures and inscriptions on them.

Amongst the proceedings of the Society it is interesting to observe how much mutual assistance is evinced between the promoters of Oriental literature in Europe and those in Asia. Dr. Weber writes an account of the progress of such work in Europe, especially in Germany, noticing the appearance of the second volume of Pictet's 'Origines Indo-Européennes,' and regretting the scholastic employments of Kuhn did not allow him to devote his whole time and attention to comparative mythology. A discussion on the Andaman Islanders arose at one of the meetings, after a paper read by the Rev. Wm. Corbyn. We are very glad to perceive that the indolent and unscientific argument that when a civilized and powerful race comes in contact with an ignorant and degraded people, the extermination of the latter must follow as a natural consequence, was met and combated by Mr. Cowell (whose return to England in consequence of ill health will be a great loss to this Society, to the college of which he is such a distinguished professor, and to Indian literature generally) and also by the president. The latter adduced as an instance in point the case of the Laps in conjunction with the Russians. That nation has neither decreased in numbers nor deteriorated in condition since the commencement of the last century; but then they have neither been subject to the example of the most degraded specimens of vicious civilization, harassed by petty injustice, nor enticed into such courses as must lead to their destruction. Great praise is due to Mr. Corbyn for what he has done and is doing for this almost hopeless race of human beings.

The journal concludes with an elaborate abstract of the meteorological observations taken at the Surveyor-General's office at Calcutta,

from August, 1863, to the end of the year. The following results may be noticed:—

	Inches.
The maximum height of the barometer was on December 19th, at 10 a.m.	30·153
The minimum height on the 17th August, at 5 a.m.	29·35
The mean daily range of the barometer during August	0·109
" " " September	·124
" " " October	·124
" " " November	·125
" " " December	·134
The greatest range of the barometer in one month was in October, of an inch	·48
The maximum temperature in August	90·6
" " September	90·6
" " October	90·4
" " November	86·3
" " December	79·7
The minimum temperature in August	75·4
" " September	77·8
" " October	72.2
" " November	61·6
" " December	56·4
The total amount of rain that fell in August (24 days)	14·1
" " " September (23 days)	10·33
" " " October (9 days)	3·48
" " " November (3 days)	1·26
" " " December	nil.

REVIEWS.

THE SCIENCE OF LANGUAGE.*

THE Science of Language is in one point of view the youngest of the sciences. Though we can scarcely imagine a period at which this subject was not studied in an empirical manner, still, as a science resting on induction and logic, it has existed but a few years. Thus it is scarcely possible to state a period at which the history of Philology should begin, but it is only of late years that anything like scientific arrangements or definite laws have been discovered.

As before geology was studied scientifically, many a collector possessed a museum containing curiosities from his own neighbourhood, illustrating a particular class of rocks, so before philology (or Linguistics, as Mr. Marsh would call it) had arrived at well-ascertained laws or systematic classification, many a student of one or two languages had collected specimens of "fossil history and fossil poetry" dug from the mines of dusty books, even preserved from the rubbish-heaps lying at his doors, all which material will one day be arranged and labelled and inserted in catalogues, causing their language to become to the learned "a dictionary of faded metaphors."

The man who seems to have been the first to recognize the necessity of extensive induction before general laws could be discovered was Leibnitz, the contemporary of Newton. In order to place this study on a really philosophical basis, he entreated all those who had any chance of assisting him—such as missionaries, travellers, &c.—to collect the elements of whatever strange dialects it might be their fortune to meet with. Leibnitz possessed the advantage, not common to great thinkers, of being intimate with some of the leading political characters of his day, and amongst others with the Czar, Peter the Great. To the Emperor of all the Russias this philosopher pointed out the immense advantage that might be derived at small cost to the Russian Government, if he would cause the numerous dialects of the various races under his rule to be committed to writing. No immediate fruit resulted from this advice, but nearly a hundred years later the Empress Catharine took up the idea, and devoted a considerable amount of time to the work of compiling a Comparative Dictionary. For this purpose she procured lists of words, not only from her own enormous dominions, but by means of ambassadors from various parts

* 'Lectures on the Science of Language' delivered at the Royal Institution of Great Britain in February, March, April, and May, 1863. Second Series. By Max Müller, Fellow of All Souls College, Oxford; Correspondant de l'Institut de France. London: Longmans, 1864.

'Philological Papers.' By J. A. Picton, F.S.A., President of the Literary and Philosophical Society of Liverpool, 1864. Printed for private circulation only.

of the known world, even from the Indians of North America, specimens of whose languages were procured for her by Washington. In this dictionary 283 words were translated into 51 European and 149 Asiatic languages. The suggestions of Leibnitz gave rise during the last century to other works of a similar character, 'The Catalogue of Languages' by Hervas, and the 'Mithridates' of J. C. Adelung. But that which gave the greatest impetus to the study of Philology was the commencement of the knowledge of Sanskrit in Europe. The first Europeans who acquired any knowledge of this tongue were certain Jesuit missionaries: missionaries have frequently been the first to become acquainted with the speech of uncivilized tribes. Robert de Nobili, in 1606, was the first to acquire a knowledge of this tongue, by adopting the habits, costume, and to a certain extent the religion of the Brahmins. The French missionaries sent by Louis XIV. under Father Pons, in 1697, followed, and their works excited the first curiosity felt in Europe on the subject of the language. The first grammar was published in Rome, in 1790, by Johann Philip Wesclin, better known as Paulinus a Santo Bartolemeo. The early members of the Asiatic Society of Bengal, the great Sir William Jones, Carey, Wilkins, Foster, Colebrooke, and others, studied assiduously the literature of the Brahmins, and published the results of their labours for the benefit of other Europeans.

Frederick Schlegel happened to be in England at the time when Sanskrit first became a subject of general discussion among the learned. With the prophetic insight of the poet, he saw at a glance the widespread connection of the languages of the peoples reaching from the Ganges to Iceland, and chronicled his idea in the scarcely yet superseded word—Indo-European. Since then, step by step, the science has gained footing among the learned men of Germany, of England, of France, and of India.

There are several reasons why philology should be studied in England. In the first place there is the mixed nature of our own language; on a groundwork of Saxon phraseology and of Saxon grammar we have grafted what in many cases differs but little from it, a good deal of Norse, much more Norman-French, and in the more scientific subjects Latin and Greek terms in abundance. Again, belonging thus to the Low-German family of tongues, the language from which most of us gain our knowledge of grammar and our first acquaintance with a mode of speech not our own, is the Latin, one of the family of classical tongues. And lastly, our extensive dominions in the East demand on the part of many of our most independent thinkers an acquaintance with the eldest sister of the classical family, *viz.* Sanskrit, an acquirement which, on their return to Europe unconnected with the politics, the science, or the fashion of the day, gives employment to a learned leisure more consonant with its previous employments. Thus philology in England has employed the *horas subsecivas* of many of our quiet thinkers, whilst the increasing demand for genuine classical education, combined with a knowledge of modern languages of the Romance, or High German type, serves to introduce the youth of our time to the principal branches of the Aryan family. The

thorough mastery of grammar, moreover, demanded by the Universities paves the way for, and almost demands, some attention for Comparative Grammar. Thus in England lectures on the Science of Language both at Oxford and in London are attended by a large and varied audience; and we have no doubt that Mr. Picton, at Liverpool, received the same attention from the learned societies for his interesting and instructive papers as Professor Max Müller obtained for his deeper and, therefore to the multitude, less interesting communications, written in such English as few Englishmen can hope to attain, and delivered with an accent so slightly foreign as to cause in the hearer envy of such facility in acquiring a strange tongue. The style of the author throughout is so fascinating, so clear, and so well calculated to lead one to admire the subject on which he dilates, that it is with difficulty we refrain from quoting long passages from this work on a subject which most people are wont to think dry and uninteresting. We are sure the extracts we do give will bear out this remark. We can only regret that we must spoil much by abridgment, and we hope we may induce our readers to imbibe more copiously from this "pure well of English undefiled."

The sources whence the science of language expects to receive additions are manifold. The languages of remote and barbarous peoples—for instance, Southern Africa and Polynesia—contribute their share of enlightenment to the missionaries who study them; but nearer home, in the dialects of our own villagers and of our ancestors, the more stay-at-home people may find not only amusement but instruction, and may deduce from what they there find, generalizations that will throw much light on investigations of subjects less well known. Thus the expressions, "He is a-going, I am a-coming," &c., afford the Professor an opportunity for a dissertation of some pages, and a comparison with not only Anglo-Saxon, Gothic, and Old and Modern High German, but also with the distinct dialects of French, Bengali, and Bask. From these comparisons we may find principles that will hold good in the ancient tongues; thus all alike assist in the research; modern forms throw light upon antiquity; *agglutinative* explains *inflectional* formation; whilst the *radical* stage of Chinese and its neighbours explains the earliest condition of the Aryan and Semitic families. The rapid change in the languages of nomadic tribes is seldom sufficiently reckoned. Whilst the antiquity of Man upon this earth is being supported by every possible argument, the yet unbridged gulf between the Aryan and the Semitic families affords a specious argument for an enormous lapse of time between the separation of these peoples and the subdivision of the families themselves. But if this rapid variation of the dialects of nomadic tribes be considered, this period should be greatly shortened if we can trace any analogy whatever between the tongues. In this matter much still remains to be done, yet there are many points of contact that cannot be ignored, and when these are more clearly developed, we think the enormous ages must be somewhat shortened. Professor Müller does not bring forward this argument, but he gives several instances of the peculiar causes which lead to change in unsettled and

unwritten tongues, causes which would never occur to our minds were not instances brought under our notice. A remarkable case is as follows:—

"The Tahitians, besides their metaphorical expressions, have another and more singular mode of displaying their reverence towards their king, by a custom which they call *Te pi*. They cease to employ in their common language those words which form a part or the whole of the sovereign's name, or that of one of his near relatives, and invent new terms to supply their place. As all names in Polynesian are significant, and as a chief usually has several, it will be seen that this custom must produce a considerable change in the language. It is true that this change is only temporary, as at the death of king or chief, the new word is dropped and the original term resumed. But it is hardly to be supposed that after one or two generations the old word should still be remembered and reinstated. Anyhow it is a fact that the missionaries, by employing many of the new terms, give them a permanency which will defy the ceremonial loyalty of the natives. Vancouver observes that at the accession of Ótu, which took place between the visit of Cook and his own, no less than forty or fifty of the most common words which occur in conversation had been entirely changed. It is not necessary that all the simple words which go to make up a compound name should be changed. The alteration of one is esteemed sufficient: thus in *Po-mare*, signifying "the night (*Po*) of coughing (*mare*)," only the first word *Po* has been dropped, *mi* being used in its place. So in *Ai-mata* (eye eater), the name of the present queen, the *Ai* (eat) has been altered to *amu*, and the *mata* (eye) retained. In *Te-arii-na-vaha-roa* (the chief with a large mouth), *roa* alone has been changed to *maoro*. It is the same as if with the accession of Queen Victoria either the word *victory* had been tabooed altogether, or only part of it, for instance, *tori*, so as to make it high treason to speak during her reign of *Tories*, this word being always supplied by another such, for instance as Liberal Conservative. The object was clearly to guard against the name of the sovereign being ever used, even by accident, in ordinary conversation, and this object is attained by tabooing even one portion of his name." *

Another cause of variation is found more especially among the Kafirs. The women never pronounce any word which contains a sound similar to the names of their male relatives. In many languages the influence of women has given a peculiar turn to the speech of the whole nation. Thus Dante ascribed to the ladies of Italy, who did not understand Latin, the first patronage of literature in the vulgar tongue. Our author goes on to divide many languages into two dialects; "one showing a more manly, the other a more feminine, character." He instances "Greek in its dialects, the Æolic and the Ionic, with their subdivisions the Doric and Ionic;" High and Low German; in Celtic, the Gadhelic and Cymric; in India, the Sanskrit and Prâkrit; and, following the suggestion of Grimm, he believes—

"The stern and strict dialects, the Sanskrit, the Æolic, the Gadhelic, to represent the idiom of the fathers and brothers, used in public assemblies; while the soft and simpler dialects, the Prâkrit, the Ionic, and the Cymric, sprang originally from the domestic idiom of mothers, sisters, and servants at home."

* P. 34.

To this we must demur that whilst the Æolic and Ionic, the High and Low German, the Gadhelic and Cymric were contemporaneous and concurrent, the Prâkrit was a corruption and successor of the Sanskrit; that supposing the Ionian might be considered more polished and more effeminate than the Æolian, the Englishman, the Dutchman, and the Dane have never shown themselves inferior in courage (though they may have been in numbers) to the Prussian or the Austrian. With all respect for Grimm and for Professor Max Müller, we must dissent from a doctrine which is methodical enough to have issued from a French bureau.

With one of the author's conclusions, on which he lays much emphasis, we cannot bring ourselves to agree. He says: "*Without speech no reason, without reason no speech.*" * And again: "We cannot realize general conceptions, or, as they are called by philosophers, nominal essences, such as *animal*, *tree*, *man*, without names; we cannot reason therefore without names or without language." † It may be that in our present condition as civilized beings, having a language on which to rely, we usually do not reason without language. It may be that children before they can speak do not reason, and it may be that the whole logical syllogism cannot be developed without the use of language. But are we in a condition to judge of those who had no language? Did not reason exist in the mind previously to the utterance of language? Do we not even see the glimmerings of reason existing in animals in whom we find no language? Professor Huxley declares that language is the only differentia of man perceptible by the senses; but are we to deny to the whole brute creation that reason which has of late years been able to trace its own image reflected in that darkened glass which indifference and laziness have termed instinct? We might as well say, as many a so-called logician would say, that reasoning could not exist without a syllogism. This is perfectly true in a certain sense. We cannot arrive at certain ends without a certain amount of machinery as a rule, but still we do not know whether we cannot arrive at those ends without the machinery if we have not the ordinary means at hand. All reasoning must be capable of being put into the form of a syllogism, and therefore must be capable of being put into words, but we cannot put ourselves entirely into the position of those who have no words to use, and therefore we cannot tell whether they could not reason without words in such a form as we should be able afterwards to put into words. In one case the author gives an instance against himself. He says—

"The history of religion is in one sense a history of language. Many of the ideas embodied in the language of the Gospel would have been incomprehensible and inexpressible alike, if we imagine that by some miraculous agency they had been communicated to the primitive inhabitants of the earth. Even at the present moment, missionaries find that they have first to educate their savage pupils, that is to say, to raise them to that level of language and thought which had been reached by Greeks, Romans, and Jews, at the beginning of our era, before the words and ideas of Christianity assume any reality to their minds, and before their

* P. 65. † P. 435.

own native language becomes strong enough for the purposes of translation. Words and thoughts here as elsewhere go together; and in one point of view the true history of religion would, as I said, be neither more nor less than an account of the various attempts at expressing the inexpressible."

Here, at least, it is quite clear that the words are entirely wanting because the ideas are unknown, but the idea must first be formed, and the word follows as a matter of course. To take the old metaphor, the shadow *follows* the substance; it is quite true we cannot separate the one from the other; the Peter Schlemihl process is inhuman and monstrous, but the substance is antecedent to the shadow according to all logic. The word ἀγάπη existed before St. Paul's time undoubtedly; here the coming event cast its shadow before; but Christian charity existed in the thoughts and in the life of the Apostle before the Epistle to the Corinthians was penned. Again, many a mathematician sees clearly the whole reasoning of the proposition without going through a word of it; but to put this reasoning into words is a long and laborious process afterwards. A glance at a diagram places the whole train of thought instantaneously before his mind, which it may require hours to reduce to words. The truth of the matter is, Professor Müller has for once been led away by words. Clearly as he is able to see the tendency that words have to cloud the brightest intellect, he has allowed the Greek Logos to confuse his own mind. The collection of instances, the conception and birth of the idea, and the naming, that it may be known by others, are distinct processes. And again, Professor Max Müller instances* a statement of Herodotus, "that the Pelasgians for a long time offered prayer and sacrifice to the gods without having names for them," though he says this "rests on theory rather than fact, yet even as a theory the tradition is curious." Thus a Greek, in spite of his own language (and we know how much the language of Greece and the fanciful derivations of its philosophers influenced their theories), separated the logos spoken from the logos unspoken. Herodotus, who, truthful and honest as he was, was not more clear-headed than Plato and Aristotle, yet could allow a distinction that our great philologist, who usually knows so well the value of words,† mere words, does not see and will not allow.

The second lecture enters into an elaborate account of Bishop Wilkins' proposal for a universal language. The artificial is here plainly distinct from the natural. The next step is to go back as far as investigation will allow towards the origin of language. Here roots, not letters, seem at present to be the "ultimate residuum of complete analysis" of a class of languages. These roots give us all the words with which we are acquainted, but how these roots originated does not at present appear, at least so says the professor. The theory of onomatopœia has been so obstructive to real philological progress, that we cannot be surprised that it is not allowed standing-room in the new science. The bow-wow theory, as Max Müller calls it, receives hard treatment both in these and in the former lectures. Roots must

* P. 435. † P. 560. "They rule the mind, instead of being ruled by it."

have originated in some way; either the sound of the object or the expression of the subject must have been the earliest utterance. It is quite possible that the actual name for a horse, or any other natural object as we at present describe it by its name, may have originated in some particular quality which has been considered striking; but how has that quality received its name? The Lithuanian *aszva* (mare), Latin *equus*, Greek ἵππος (= ἴκκος), and the old Saxon *ehu*, may all have originated in the root *aç*; but whence this root with its signification of swiftness and sharpness? Must it not have arisen from an imitation of the sound of rapid motion; a swift cutting of the air in sunder; a hiss? We do not wish, and we are not able if we wished it, to "undo all the work that has been done by Bopp, Humboldt, Grimm, and others (including not least Max Müller himself), for fifty years," but we think that no one who enters so thoroughly into the subject of tracing language to its origin can with regard to the onomatopœic or imsonic source of roots "remain entirely neutral."

We next proceed to a discussion of the alphabet. After our own language we usually suppose that the alphabet is the thing we know best of all our acquirements. How much there is still to learn even on this subject is best seen from the work under review. We cannot pretend to give an abstract of the author's remarks on this subject, inasmuch as it would require the plates with which he illustrates his text to make the matter plain to our readers. Suffice it to say that he relates the divisions and accounts of letters given by writers of various nations and periods, explains the formation of different sounds as revealed by the laryngoscope (a small looking-glass which enables the experimenter to look down the throat of the patient whilst he speaks), depicts the physiology of pronunciation, and shows how easily one class of sounds may be merged into another. On the exceeding intricacy of this subject he has a passage which we must quote as a specimen of the style and diversity of acquirements of the learned author:—

"After thus taking to pieces the instrument, the tubes and reeds of the human voice, let us now see how that instrument is played by us in speaking or in singing. Familiar and simple as singing or music in general seems to be, it is, if we analyze it, one of the most wonderful phenomena. What we hear when listening to a chorus or a symphony is a commotion of elastic air, of which the wildest sea would give a very inadequate image. The lowest tone which the ear perceives is due to about 30 vibrations in one second, the highest to about 4,000. Consider then what happens in a *Presto*, when thousands of voices and of instruments are simultaneously producing waves of air, each wave crossing the other, not only like the surface waves of the water, but like spherical bodies, and, as it would seem, without any perceptible disturbance. Consider that each tone is accompanied by secondary tones, each instrument has its peculiar *timbre*, due to secondary vibrations; and lastly, let us remember that all this crossfire of waves, all this whirlpool of sound, is moderated by laws which determine what we call harmony, and by certain traditions or habits which determine what we call melody, both these elements being absent in the songs of birds; that all this must be reflected like a microscopic photograph on the two small organs of hearing, and these excite not only perception, but perception followed by a new feeling even more mysterious, which we call either pleasure or pain, and it will be clear that we are sur-

rounded on all sides by miracles transcending all we are accustomed to call miraculous, and yet disclosing to the genius of an Euler or a Newton laws which admit of the most minute mathematical determination."

Having investigated all the possible letters in an alphabet, we may next examine what portions of the ideal alphabet are possessed by individual languages. Here we find that English and Hindustani, tongues made up of the admixture of several elements, retain and blend the peculiarities of each of their component parts. Thus, while we possess the Gothic *w*, we also have equivalents coming back again through the Norman-French in *gu*, as wise and disguise, wily and guile, &c. Again, *ch* and *j* are Romance or Norman, nevertheless these sounds are introduced into Saxon words, as *choose* (ceósan), *chew* (ceowan), *child* (cild), *cheap* (ceap), *birch*, *finch*, *speech*, *much*, &c.

The Mohawks, the so-called Six Nations, and other natives of North America, have no labials. The Society Islanders have no gutturals, in which the Semitic languages are so strong. Rather unfortunately the first Englishman with whom they became acquainted was one whom they could only call Captain Tute (Cook), a pronunciation that we might match in our nurseries. Dentals exist in every known tongue, though Chinese, Mexicans, Peruvians, Hurons, and several other dialects of both South and North America never pronounce the *d*.

"So perfect a language as Sanskrit has no *f*, no soft sibilants, no short *e* and *o*; Greek has no *y*, no *w*, no *f*, no soft sibilants; Latin likewise has no soft sibilants, no *b*, *φ*, *χ*. English is deficient in guttural breathing, like the German *ach* and *ich*," &c. &c.

Hindustani (admitting Sanskrit, Persian, Arabic, and Turkish words) has 48 consonants; Sanskrit, 37; Turkish, 32; Persian, 31; Arabic, 28; Zulu Kafir, 26, besides clicks; Hebrew, 23; English, 20; Greek, 17, of which 3 are compound; Latin, 17, of which 1 is compound; Mongolian, 17 or 18; Finnish, 11; Polynesian, 10 (no dialect has more—some less); some Australian have 8, with three variations; the Melanesian dialects have 12, 13, 14, and more consonants. Even when the same consonant does occur in two languages, slight shades of difference of pronunciation make it almost impossible to write down the sounds of an unknown tongue. An amusing instance is given of an American gentleman who resided for a long time at Constantinople, but who was sure of the pronunciation of no word in the Turkish language but what he wrote *bactshtasch*, meaning *bakhshish*. *L*, *r* are frequently mistaken, and in Hawaian it is almost impossible to distinguish between *k* and *t*; thus their late king's name is written indifferently Tamehama or Kamehama. Occasionally certain pronunciations are slurred over by certain individuals. Without Professor Max Müller's diagrams most of us know some one who would call *three*, *free*, and have heard *nothing* called *nuffen*.

Many of the changes which have been reduced to rule may be attributed to *phonetic decay*, a most agreeable euphuism for laziness. Laziness leads us to drop some letters, and to slur over the pronunciation of others, combining two into some third sound. Thus, *père* and *mère* are easier to pronounce than *pater* and *mater*; the English *night* is

easier than the German *nacht*. The following are specimens of this kind of change:—

A.S. hafoc	becomes	hawk.	*A.S.* nawiht	becomes	nought.
„ dæg	„	day.	„ hlâford	„	lord.
„ fæger	„	fair.	„ hlœfdige	„	lady.
„ secgan	„	say.	„ sœlig	„	silly.
„ sprecan	„	speak.	„ bûton	„	but.
„ folgian	„	follow.	„ heáfod	„	head.
„ morgen	„	morrow.	„ nose-thyrel	„	nostril.
„ cyning	„	king.	„ wîf-man	„	woman.
„ wëorold	„	world.	„ Eofer-wic	„	York.

Again,

Lat. scutarius.		*Fr.* escuier.		*Eng.* squire.	
„ historia.		„ histoire.		„ story.	
„ Ægyptianus.		„ Egyptian.		„ gipsy.	
„ extraneus.		„ estrangier.		„ stranger.	
„ hydropsis.				„ dropsy.	
„ capitulum.		„ chapître.		„ chapter.	
„ dominicella.		„ demoiselle.		„ damsel.	
„ paralysis.		„ paralysie.		„ palsy.	
„ sacristanus.		„ sacristain.		„ sexton.	

From laziness a letter may even be added; thus it is easier to pronounce—

Eng. thunder	than	*A.S.* thunor.		
Greek ἄνδρες	„	ἄνερες.		
„ ἀμβροσία	„	ἀμροσία.		
„ μεσημβρία	„	μεσημ(ε)ρία.		
Eng. gender	„	*Fr.* genre.		
„ slumber	„	*A.S.* slumeriar.		
„ embers	„	„ æmyrie.		
„ cinders	„	*Lat.* cineres.		
„ humble	„	„ humilis.		

We now come to the great principle of change called Grimm's law. The author introduces this merely for the sake of explaining what he considers to have been the origin of this diversity. He gives the law, indeed, in all minuteness, and explains the change of every letter, giving an example or two; but we think it a pity that in the present state of ignorance on these matters amongst the majority of students, there should be no work in the English language to which we could turn for so many examples as would satisfy the seeker after the most perfect induction. We do not say this simply to pick holes, for we are thankful enough for what the author has given, a great deal of which is much newer, and to deep students much more valuable, than the explanation of a known law; but day after day we find men who profess to be philologists, who have read many works on these subjects, publishing derivations implying most reckless violation of this fundamental change.

And here we must take leave of this interesting and learned work.

There is still much in it on which we have not touched, feeling that it was better to go through carefully the etymological portion, and to leave the mythology possibly for some future opportunity. In this latter subject the author has done much service to a study of the classics, by pointing out that the ancients possessed a religion apart from their mythology; that it was not left entirely for philosophers to speculate on the existence of the gods; but that there was something beyond the sky in which the herdsman and the slave could trust and rely; that this was (Acts xvii. 22, &c.) "the Lord of heaven and earth;" that "they might feel after him and might find him;" and that all men, and not only Jove-born kings and rulers, "are also his offspring." How the layer of superstition was spread thickly over all this deeper feeling is traceable in words—empty words, which men think are their servants, but which are frequently their masters, and which, like all created things, are hard taskmasters when they get the dominion. This mastery of words over men is not confined to the days of heathendom; the legends of the saints, the fairy tales of our youth, the stories of physical wonders in the middle ages, have in many cases their origin in a confusion of thought arising from the similarity of sound between two words entirely distinct and unconnected. This part of the subject we must leave alone, regretting that we cannot follow further through the author's lucid and thoughtful pages, and regretting too that in many cases we have been obliged to put in our own abbreviated form what he has dilated upon with such elegance and fluency of style.

We have left ourselves but little space to speak of the work of Mr. Picton. It is highly creditable to a provincial society that it should be able to elicit such excellent papers from its members. The subject of the Gothic language, important as it is to us if we would understand the roots of our own tongue, is seldom so carefully studied as it evidently has been by our author. A good knowledge of Anglo-Saxon, Gothic, and Norse is becoming every day more important to everyone who would wish to master thoroughly his native English. At the same time it is well to see that the general affinities of the language are studied in its relationship to Sanskrit. We are therefore thankful for the paper on 'Sanskrit Roots.' Of course in this paper we do not discover anything very new. The development of Grimm's law, and the exceptions to it, need to be brought clearly before the general body of English readers. The deeper scholars seem to be too much engaged with their researches to find time to explain and exemplify thoroughly this important principle of philology. We are therefore glad to welcome the exposition of it, and the examples given by Mr. Picton, as likely to be read by many who would be afraid of so large and learned a work as that of Professor Max Müller. In his last paper on 'Architectural Terms' Mr. Picton has done good service to philology, in seeking in the history of his own art for an explanation of the terms used therein. If men of science would thus chronicle what they discover in their researches in their own department, we should not have so many crude guesses or such wild metaphors put forth in the name of veritable etymology.

SPIDERS OF GREAT BRITAIN AND IRELAND.*

It is always a satisfactory consummation when the labour of a lifetime appears before the world, prepared and revised under the immediate supervision of its author; and it is no less a matter of congratulation to see a man who, in the decline of years, has accomplished his work, and lives to enjoy the satisfaction arising from the completion of a laborious task. We therefore congratulate the Natural-History public upon the appearance of the second and concluding portion of this important work, and we congratulate Mr. Blackwall upon the production of the beautifully-illustrated monograph which forms the subject of this notice—a monograph which, for completeness of detail, for care and labour of research, for richness and beauty of illustration, and for zoological interest, may well claim comparison with any with which we are acquainted.

To people in general there is something peculiarly repulsive in the notion of spiders, and their rapacity and ferocity, added to their cunning, and a certain indistinctness of information upon the subject of their poisonous properties, place them under a general ban, such as is shared by the toad and suchlike "ugly and venomous" creatures. And this has probably been the reason why spiders have met with so little attention; so that an investigation of the natural history of the spiders of these islands has opened a field hitherto to all intents and purposes unworked. Indeed, all the Zoologists who have devoted themselves to these really interesting creatures of late years have been Continental observers, particularly those of France, Sweden, and Germany, although one of the earliest Arachnologists was our distinguished countryman, Dr. Martin Lister. Of his treatise, published in 1678, Mr. Blackwall observes, that "in his admirable *Tractatus de Araneis* he has given us a classification of the species he has so ably described, founded on their external organization and economy, which has formed the basis of every subsequent attempt, deserving notice, to effect a systematic arrangement of this interesting order of animals."

The points of interest in the economy and habits of Spiders are numerous, and are likely to receive especial attention from new observers, who will receive an impulse to their studies from the appearance of Mr. Blackwall's admirable monograph. The eyes are taken as a simple and easy basis of classification. On this principle three tribes have been founded, which include all the species hitherto discovered, *viz.* Octonoculina (eyes 8), Senoculina (eyes 6), and Binoculina (eyes 2). Of these the first tribe is by far the most extensive; the second contains ten or eleven genera; while the third has been constituted for the reception of a single genus (Nops), containing two species of extra-European spiders. The head and chest (forming together the cephalo-thorax) are continuous, but the head is easily distinguishable by the presence of the pairs of smooth, simple eyes,

* 'A History of the Spiders of Great Britain and Ireland.' By John Blackwall, F.L.S. Two Parts, 4to. 1861–4. (Ray Society.)

by the *falces*, usually but improperly termed mandibles, which are terminated by a pointed fang, having a ginglymoid movement, and by the oral apparatus. Eight legs of seven joints each, having two or more claws at their extremity, are articulated round the cephalothorax, to which the abdomen, covered with a leathery or horny plate, is united by a short cartilaginous pedicle. Of course the spinning organs claim especial attention, consisting of four, six, or eight mammulæ, situated immediately below the anus, and each composed of one or more joints, from the terminal joint of which five movable papillæ arise, whence issues the viscous secretion of which the silken lines produced by spiders are formed. These are connected with special organs for the formation of this secretion, consisting of intestiniform vessels, having at their base some small supplementary canals. The viscous substance hardens immediately on exposure to the air, forming delicate filaments, which unite to form a common thread.

The falces are used for seizing, killing, and retaining the prey; but a remarkable function is claimed for the palpi. In male spiders, the digital joint of these organs, which are situated on the maxillæ, is commonly short, oval, and dilated, and have the sexual organs (which are thus double) attached within and partially concealed by a cavity on its under side. This view of the nature of the palpi was adopted by Lister, and recent researches, conducted with the utmost caution, have clearly established the accuracy of the opinion. In the females, the palpi are for the most part terminated by a curved pectinated claw.

Spiders change their skins several times before they reach maturity, after each process remaining for a short period in a state of great exhaustion. So also, like Crustacea, they have the power of reproducing detached or mutilated limbs, palpi, or spinners, but only at the period of moulting. Such a mutilated leg may be renewed four or even six times consecutively during the period of immaturity.

The ingeniously-constructed nets or webs which are so familiarly known to all are of several kinds, characterizing different groups of spiders; some of these have not much pretension to elegance of design, but nevertheless well fulfil the purpose of a snare, for which they are intended. The circular geometric nets of the Epëiræ, however, are really wonders of art. An elastic spiral line thickly studded with minute globules of viscid gum, whose circumvolutions are crossed by radii converging to a common centre, and apparently formed of a different material, being unadhesive and very much less elastic. So also the central convolutions are free from the adhesive material, and these form a look-out station from which the spider may keep watch. With regard to the viscidity of the spiral web, light has been thrown upon its nature even since the publication of Mr. Blackwall's work, the first part of which appeared in 1861. He there calculates that the minute globules which stud the lines and give rise to the viscidity are so closely ranged as to give an average of twenty globules upon one-tenth of an inch; and basing upon this calculation, he finds that a large net of *Epëira apoclisa*, 14 or 16 inches in diameter, contains upwards of 120,000 viscid globules, and yet the spider will complete

its snare in about forty minutes, if it meet with no interruption. Mr. Richard Beck, in a paper read before the Microscopical Society in 1862, stated that, by examination with a lens of a spider in the act of spinning a geometric web, he had convinced himself that when the thread left the spinnaret no dots were apparent, but that the change was one which took place afterwards and gradually. At first, slightly thicker than ungummed threads, the viscid secretion soon began to form undulations, and eventually separated, forming globules, *by molecular attraction*, at very regular and very minute intervals. It thus appears that a physical law produces the marvellous results formerly attributed to the direct agency of the spider.

It will hardly surprise us to learn that these regular webs are constructed in absolute darkness, without the slightest irregularity of plan or defect of structure; nor that young spiders display in their first attempts the most consummate skill as the most experienced individuals. Nor should the aërial flights of the aëronautic spiders be passed over in silence—excursions which appear to have a migratory instinct as their impulse. These flights are undertaken by the agency of long buoyant threads, which are not *darted* from the spinnarets, and thus propelled to a distance, as was long imagined, but simply ejected gradually, and carried upwards at the same time that they are solidified by the ascending current of air.

To those who are acquainted with the garden-spider, the house-spider, and the *money-spinner*, and whose knowledge of Arachnology, perhaps, then meets with a termination, it will be matter of profound astonishment to hear that the laborious and indefatigable researches of Mr. Blackwall have resulted in the description of upwards of three hundred species of spiders as occurring in Great Britain and Ireland. These are distributed through only thirty-four genera, allowing therefore an unusual number of species to a genus. Indeed, the genus *Linyphia* has thirty-three species; the genus *Epëira*, thirty-one species; *Walcknaera*, thirty-two species; and *Neriëne*, forty-eight. This is a much larger proportion than usually falls to the lot of a well-constituted genus, and probably it will hereafter be found desirable further to subdivide such comprehensive genera; although we do not for a moment call in question Mr. Blackwall's judgment as to this present arrangement. There is another circumstance also which indicates that the practical study of the Arachnology of these islands is in its infancy, and that is the fact that the observers who have co-operated with Mr. Blackwall are so few in number, the chief being two or three gentlemen well known for their attachment to this branch of Zoology, *viz.* Mr. R. H. Meade, Rev. O. Pickard-Cambridge, Rev. Hamlet Clark, and Mr. J. Hardy; while the cabinet of Mr. F. Walker, of the British Museum, has yielded many rare and interesting species; and Mr. R. Templeton has done much for Ireland. As a matter of course, the researches of these gentlemen could be conducted only over a limited extent of country, and the frequent repetitions of the same locality show at once the extreme and praiseworthy industry of these gentlemen, and the great need there is of energetic search in other parts of the country. Of course the vale of Llanrwst has been well

scoured by Mr. Blackwall himself, and has yielded a wonderful harvest. Crumpsall, near Manchester, Southport, near Liverpool, and Oakland are localities constantly recurring, from the accidental circumstance that one or other of the above active observers have been located at these spots. The frequent record, too, of a species as having only once been met with proves that more workers only are necessary, not only to elucidate the distribution of spiders over the British islands, but also greatly to increase the list which Mr. Blackwall has already swelled to so large a size.

In concluding this brief notice of a work of great value and importance, we cannot but pay a just tribute to the Ray Society, under whose auspices the work has been produced—a beautifully-printed quarto work of 400 pages. It is magnificently illustrated with twenty-nine plates, containing many hundred figures, for the most part coloured, including a coloured representation of every species, and often two such figures of a species, and numerous interesting details. Such a work could hardly have been undertaken by a private publisher, but by such a subscription society it has been produced in two parts, at one guinea each part to subscribers. There could be no stronger proof of the value of such a combination, and although the second part has been somewhat delayed on account of the plates, we trust that the Ray Society will meet with additional support on account of this transaction. It has passed through some difficulties, but we hope it has seen the end of them, and that under the direction of its present energetic secretary, a long career of usefulness may be before it. Our thanks are due to Mr. Blackwall for his splendid contribution to the Zoology of these islands, and we may congratulate him on their having been so admirably laid before the public, with, as we are told, considerable pecuniary outlay on the part of the author.

POPULAR WORKS ON BOTANY.*

The study of Botany has of late years been much extended, both as regards the curricula of universities and the course of lessons given to the young. Popular works have multiplied,—most of them illustrated by woodcuts, plates, or coloured drawings, which add much to their interest and usefulness. 'Rambles in Search of Wild Flowers,' by Miss Margaret Plues, is a work of this nature. In the introductory portion a description is given, in familiar language, of the various organs of plants; the principles of the natural system of classification are explained; and the classes and sub-classes are defined. The natural orders are then described, and some of the common plants in each are noticed in an instructive manner, illustrated by coloured

* 'Rambles in Search of Wild Flowers, and How to Distinguish them.' By Margaret Plues. London, 1863.

'Rambles in Search of Flowerless Plants.' By the same Authoress. London, 1864.

drawings, which upon the whole are well executed. In the course of the descriptions occasion is taken to notice the various forms of root, stem, leaves, flowers, and fruit; and the youthful readers are led in a very pleasing and attractive way to notice the wild flowers which are strewn around them. Lessons are also given in regard to the plants of Scripture as occasion offers, and the thoughts are directed to the contemplation of the wisdom and goodness of the Creator. In one of the volumes Miss Plues confines her attention to flowering plants, beginning at the Ranunculuses and ending with Grasses. In the other volume she considers the flowerless plants, as Ferns, Mosses, Lichens, Seaweeds, and Fungi. These works cannot fail to be useful to those who wish to enter on the study of native plants, and they are pleasing companions in country rambles.

PAMPHLETS.

On Vitality. By the Rev. H. H. Higgins, M.A.*

Of the various questions which the physiologist is called upon to consider in the course of his researches into the phenomena exhibited by organized beings, none perhaps possesses greater interest than the one discussed in this short but able pamphlet by Mr. Higgins. Is there, or is there not, a force resident in those bodies which, from their special manifestations, we term organisms or living beings, over and above those chemico-physical forces the nature and mode of action of which we recognize and especially study in inorganic bodies? This force has had various terms applied to it by those who affirm its existence, *e. g.* vital force, germ force, vital principle, or vitality, as in the pamphlet before us.

The older physiologists, we may say, universally believed in such a specific organic force, and sought in it an explanation of most of the phenomena to the investigation of which they applied themselves. But the more refined methods of inquiry adopted in recent years have proved that there is no need to presuppose the existence of a specific vital force acting in many of these processes, for they are perfectly explicable by the operation of well-known chemico-physical laws. For it must ever be kept in mind that an organism is a material body, and as such is subjected to the action of those forces which operate in and on matter, though these are undoubtedly modified and often rendered more complicated and difficult to recognize than in inorganic matter. Hence has arisen a physiological school, whose leading members are some of the most brilliant and distinguished of living German physiologists, who, from the results which they have obtained by applying to the investigation of organic processes the methods of chemico-physical

* Read before the Liverpool Literary and Philosophical Society, January 11th, 1864.

research, have been led to deny altogether the existence of any specific vital force. But whilst readily conceding that the advocates for a special vital force have claimed too great a dominion for their favourite potentate, and that many of its supposed subjects are really under the governance of other powers, yet we are by no means inclined entirely to dethrone it. We agree with our author in believing that there is a series of phenomena manifested in organized bodies which cannot be explained by chemico-physical laws, and which is not capable of being recognized even by chemico-physical methods of research.

The broad line of demarcation which separates things animate from things inanimate: the manifestation in the former of those processes which the physiologist distinguishes by the terms development, growth, and maintenance—processes which are exhibited by the simplest vegetable or animal cell as clearly as by the highest and most complicated organism, and which consist not in mere superficial accretions of new matter as in the formation of crystals, the highest of all inorganic forms and processes, but in minute interval molecular changes—points at once to the existence in the former of a specific determining power, no indication of which is met with in the latter.

"And if life were made up of forces similar to those which act in various ways both on organic and on inorganic matter, we might expect to find the transition from things inanimate to things animate the same in character with all other transactions in nature; the border-land would be occupied with semi-animate materials, and semi-mineral vegetables or animals, with instances of equivocal life and products of doubtful organization. Whereas from the highest to the very lowest organism, the phenomena of life are distinct and unquestionable."

There is a class of scientific observers—pseudo-scientific, we had almost written—who believe that, by passing electrical currents through solutions of albumen or other nitrogenized substances, they can produce in them nuclei, cells, or other well-defined organic forms; and that thus, by the operation of a well-known physical force on certain forms of matter, structures, for whose production the vitalist contends that a special force is necessary, may be generated. But it has never yet been shown that these oval or spherical cell-like forms produced in such solutions are capable of going through those processes of development, growth, and maintenance which are the characteristic phenomena of all living beings. Their morphological similarity has too hastily been assumed to be a proof of their teleological identity. As well might it be said that the arborescent appearance seen on the glass in our window-frames on a frosty winter's morning was the same thing as the trees and other plants whose form and method of branching it simulates.

We have not space to follow Mr. Higgins through the remainder of his carefully reasoned argument that the vital principle is a thing *sui generis*, but in order to give our readers some idea of its nature we reproduce in this place his general summary:—

"1st. The unparalleled hiatus which exists between things animate and things inanimate.

"2nd. The great dissimilarity between the properties of the imponderables and those of vitality.

"3rd. The difficulty arising from the hypothesis that the embryo of a living thing is developed only by agencies analogous with known forces.

"The permanence of form and structure observable during many generations of the same species.

"5th. The absence of any indications as to what becomes of the vital principle of death.

"6th. The periodicity of life."

Natural History in Jena.*

We have received the second part of the first volume of a new medical and philosophical journal, edited by the Medico-Natural Philosophical Society of Jena. The professors in the small Thuringian University are evidently determined not to be outdone by their brethren in Würzburg, Munich, and other German seats of learning. From the character of the Society under whose auspices the journal appears, the articles have a more many-sided aspect than is possessed by the papers in the well-known 'Zoological Zeitschrift' of Siebold and Kölliker; by the 'Pathological, Physiological, and Practical Medical Archive' of Virchow, or the 'Anatomical and Physiological Archiv' of Müller, now edited by Reichert and Du Bois-Reymond. Accordingly we find in it articles, On Organic Chemistry, by Alsberg, Geuther, Reichardt, and E. Schultze; On Physiology, by Von Bezold; On Anatomy, by Gegenbaur; and on various topics bearing on Practical Medicine and Surgery by Gerhardt, B. S. Schultze, F. Ried, and Schillbach. From the established scientific and practical reputation of several of the above writers we may feel assured that, if the journal is continued in the same spirit with which it has been commenced, it will form a desirable accession to German periodical literature. This blending of the scientific with the practical in the pages of the same publication is not without its advantages, not only to the practitioners of medicine and surgery, but to all men who in the pursuit of their daily bread have to follow out the details of their art without perhaps making much reference to the scientific principles on which it is based. It serves constantly to keep before them the important fact that the two ought never to be dissociated.

We would especially recommend to the notice of our readers the article, On the Influence of the Spinal Cord on the Circulation in the Mammalia, by Von Bezold, the Professor of Physiology in Jena, known as one of the most able of Du Bois-Reymond's pupils, and author of a Memoir on Innervation of the Heart; the paper, On the Episternal Arrangements of the Skeleton in Man and Mammalia, by Gegenbaur; the article, On Acetal, by Alsberg; and the Account of a Case of Resection of the entire Upper Jaw, by Ried.

* 'Jenaische Zeitschrift für Medicin und Naturwissenchaft.' Leipzig. W. Engelmann, 1864.

The Flora of the Carboniferous Epoch of Nova Scotia.*

This author states that he is more and more convinced that no satisfactory progress can be made in fossil botany without studying the plants as they occur in the beds in which they are found, or in large numbers of specimens collected from these beds, so as to ascertain the relation of their parts to each other. A catalogue is given of the plants, with descriptions of some new species. The author comes to the following conclusions:—

1. Of 192 nominal species in the list, probably 44 may be rejected as founded merely on parts of plants, leaving about 148 true species.

2. Of these, on comparison with the list of Unger, Morris, and Lesquereux, 92 seem to be common to Nova Scotia and to Europe, and 59 to Nova Scotia and the United States. Most of these last are common to Europe and the United States. There are 50 species peculiar, in so far as known, to Nova Scotia, though there can be little doubt that several of these will be found elsewhere. It would thus appear that the coal flora of Nova Scotia is more closely allied to that of Europe than to that of the United States. A curious circumstance as connected with a similar relationship of the marine fauna of the period.

3. The greater part of the species have their head-quarters in the middle coal formation; and scarcely any species appear in the upper coal formation that are not also found in the former. The lower coal formation, on the other hand, seems to have a few peculiar species not found at higher levels.

4. The characteristic species of the lower coal formation are *Lepidodendron corrugatum* and *Cyclopteris Acadica*, both of which seem to be widely distributed at or near this horizon in Eastern America, while neither has yet been recognized in the true or middle coal measures. In the upper coal formation *Calamites Suckowii*, *Annularia galioides*, *Sphenophyllum emarginatum*, *Cordaites simplex*, *Alethopteris nervosa*, *A. muricata*, *Pecopteris arborescens*, *P. abbreviata*, *P. rigida*, *Neuropteris cordata*, *Dadoxylon materiarum*, *Lepidophlois parvus*, *Sigillaria scutellata* are characteristic plants, though not confined to this group.

5. In the middle coal formation, and in the central part of it, near the greater coal seams, occur the large majority of the species of *Sigillaria*, *Calamites*, *Lepidodendron*, and *Ferns*, some of the species ranging from the millstone-grit into the upper coal formation, while others seem to be more narrowly limited.

* By J. W. Dawson, LL.D., F.R.S., Principal of McGill College, Montreal.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING AT BATH, SEPTEMBER, 1864.

THE BRITISH ASSOCIATION established itself at Bath under circumstances which at once announced to the observer of signs that it was to prove a success. The great influx of members and subscribers, even before the proceedings fairly commenced, enabled the Assistant-Secretary to state to the first general meeting that the numbers were rapidly approaching a maximum, inasmuch as no less than 2,309 had enrolled themselves, thus adding to the exchequer a sum of 2,458*l*. According to the official return, however, the attendance eventually proved less numerous than in 1863 at Newcastle, which may be accounted for by the comparatively lower population of Bath and the neighbourhood. Among the visitors were not a few distinguished in the various walks of science, and although some *habitués* of the Association might have been missed from their places, it would be more easy to say who was not there than to enumerate the *savans* who might be seen assisting at the various Sections. Such a numerous meeting fully proves how popular the Association continues to be, and how eager are the residents of our large towns to avail themselves of the opportunities afforded by the gathering of representative scientific men amongst them, and is a circumstance which may be regarded with satisfaction, as exhibiting a growing appreciation of scientific pursuits. But then great numbers have at the same time their disadvantages. Such a city as Bath, although well provided with edifices adapted for moderate numbers, seldom possesses under one roof space for such a monster assemblage as necessarily assembles at the general meetings of the Association, and the resources of its two most capacious buildings have been severely tried on these occasions. The address of the President, at which all who have arrived endeavour to be present, was delivered in the handsome theatre, which presented a brilliant spectacle, every available spot being crowded from pit to gallery, while upon the stage was assembled around the distinguished speaker the *élite* of the intellectual society of the British Isles. Sir Charles Lyell's enunciation, though low at first, soon gained a distinctness which caused him to be heard in every part of the edifice; his address, to which we devote a separate article, was listened to with marked attention, and when he arrived at that portion of it in which he declared how "fettered we have been by old traditional beliefs," the pent-up interest of the great assembly asserted itself by continued applause.

On the occasions of the *soirées*, the Assembly-rooms have been brought into requisition—apartments well adapted for such a purpose,

and connected by historical associations with the palmy days of Bath. This suite of rooms, consisting of ball-room, octagon, and concert-room, was densely crowded by a brilliant company on the second evening of the meeting. The Sections also were extremely well lodged, although it unfortunately happened that they could not all be placed under a single roof. The distance, however, between them was but small, and as soon as the visitor could make himself familiar with their relative position, it was found that they could be reached from one another without much expenditure of time. The Mineral Water Hospital afforded two excellent rooms, in which Section D (Zoology) and Section E (Geography) were located. The latter, much the largest of the two, was however not too large for the numbers which congregated in that popular Section, and was always well filled. Downstairs in the same building, the Sub-section of Physiology, less generally attractive, occupied a modest apartment, where much work, devoid of show, was transacted during the meeting. The Corridor-rooms housed the Chemists (Section B), who could not complain of their location, nor of their audience; though a considerable offshoot of the workers of this Section formed themselves into an unofficial section, under the name of the Pharmaceutical Conference, at which papers bearing on Pharmaceutical Chemistry were read and discussed. The Geologists (Section C) occupied the handsome and spacious Guildhall; the Mathematicians (Section A) found ample space in the Blue-coat School board-room in Sawclose; while the Grammar School in Broad Street housed the essentially-practical philosophers of Section G (Mechanical Science). Perhaps the Statisticians (Section F) were the only division which had any cause for dissatisfaction, the Milsom-street Rooms being inadequate for their requirements; but this was amply remedied after the first day by their removal to the spacious concert-room before mentioned.

The great influx of visitors into Bath has given rise to fabulous tales respecting the exorbitant demands made for their necessary accommodation, but these stories are, we believe, without any foundation in fact. The arrangements made with great care and trouble by the local secretaries would, indeed, suffice to render any attempts at imposition useless, and application to these gentlemen was all that was required to protect the visitor, and to ensure comfortable and reasonable accommodation. A considerable amount of private hospitality was also exercised, nor were the official representatives of the city wanting in recognition of the guests. The Lord-Lieutenant (Earl of Cork) entertained the excursionists to Frome on the Saturday, while the Countess of Waldegrave did the same for those who visited Radstock on the same day. The Mayor of Bath gave a banquet in the Guildhall on Saturday evening to a select assembly, and Mr. Tite, M.P., repeated the entertainment on the following Thursday. The citizens of Bristol also extended their hospitality to that Section of the Association which visited Clifton for the purpose of viewing the beautiful suspension bridge just completed; and many public buildings in Bath have been freely opened to the members of the Association during their stay in the city.

But while the meeting at the beautiful city of Bath will long be remembered as a successful and agreeable one, an unhappy reminiscence must inevitably be associated with it in the melancholy death of Captain Speke, the celebrated African traveller, who met with a fatal accident when shooting in the neighbourhood on the second day of the meeting. As one who had attended the Geographical Section on that very day, and who was to be the hero of a stirring discussion on the following morning, the fatal event caused a sensation in the assembled meeting more easily conceived than described, and necessarily threw a gloom over what in every other respect was a successful and agreeable gathering.

The announcement that the next meeting of the Association, in 1865, will be held at Birmingham, and that Professor Phillips, who, as Sir R. Murchison stated, has been the labouring oar of the Association, is to be its President, will be hailed by the scientific world with satisfaction.

In the following short articles we have endeavoured to place before our readers a few of the leading novelties in science which were brought before the various Sections, and our apology for the imperfection of the record must be the brief space of time at our disposal, little more than a week having intervened between the close of the Association meetings and the issue of this Journal. One of the most important papers, however, recounting the experiments of Mr. William Fairbairn upon the physical properties of submarine cables, will be found amongst our Original Articles, contributed by the author in all its details, and we shall endeavour in our next to atone for our shortcomings in the present number.

The President's Address.

With the modesty which characterizes all truly great men, and which distinguishes, *par excellence*, the President of the British Association, that gentleman confined himself in his Inaugural Address entirely to the branch of science in which he is one of the leading authorities, and in so far he has placed at a manifest disadvantage those of his predecessors (perhaps we are correct in saying all) who ventured to lay before the Association a survey of the progress made in every field of science during the year preceding their installation.

But however gratifying and interesting this new feature may have been to geologists, it is questionable whether it has met with universal approval, and whether it will not by some be regarded with satisfaction rather as an agreeable deviation from an acknowledged custom, than as a precedent to be followed by future presidents.

To many of his hearers, and more especially to his readers, it must have been a source of disappointment not to be favoured with the general survey, which is looked for by the scientific and semi-scientific public. To the Zoologist, for example, it must have been tantalizing to be conducted to the outer courts of his amphitheatre, and instead of being permitted to enter, to be left standing on the threshold whilst

his guide started off upon some special, and to him, more urgent business.

It was very unkind of Sir Charles, after having tried the patience of the long-suffering Darwinian (who of all men looks forward to these meetings for an opportunity to improve his experience), whilst he discoursed ably upon the origin and character of the Bath waters, to cut him off with a few sentences concerning the palæontological series, which he said, in confirmation of Mr. Darwin's view, it had never been "part of the plan of nature" to leave perfect "for the enlightenment of rational beings, who might study them in after-ages."

And we must be permitted here to say, by way of parenthesis, with all deference to Mr. Darwin and his illustrious disciple, Sir Charles Lyell, that the conviction has been daily becoming more firmly established in our mind, that it *did* form part of the plan of that Power which moulded nature to leave a sufficiently complete record to enable us rational beings, or rather our posterity, to grasp and comprehend the whole of its operations from the commencement; but we, too, must plead the *present* imperfection of that record as our reason for not discussing the subject.

The Astronomer and the Chemist will equally regret that the President did not favour them with a *résumé* of the progress of their respective branches of science. Spectrum Analysis, the great discovery of the day, was referred to, it is true, but only to inform the world that medicinal hot springs contain Copper, Strontium, and Lithium. What this method of analysis has done during the past twelve months to reveal the composition of the heavenly bodies, or how far it has contributed towards the progress of Chemical Science, are items of information which must be sought elsewhere.

And thus the case stands with the Mechanician, the Ethnologist, the Physicist. All these votaries of science must this year be content to seek a record of novelties in their respective branches elsewhere than in the President's Address. That, restricted as it may have been in its scope, was one of the most valuable contributions to our scientific literature, and it will undoubtedly mark an era in the history of Geological Science.

Nominally it treated of the origin and nature of the mineral waters of Bath; but virtually it dealt with the relation of the phenomena concerned in the production of all hot springs to changes in the level of the land and sea; with glacial action; with the hydro-thermal theory of the formation of crystalline rocks; with volcanic phenomena, &c. It also touched, though very briefly, upon the antiquity of man; upon the inquiry "whether clear evidence can be obtained of a period antecedent to the creation of organic beings upon earth;" and whether the changes which have taken place in the constitution of the earth's crust have been of a comparatively speaking rapid and violent, or of a slow and gradual nature.

Indeed we may repeat that, as a contribution to Geological Science, and a clear exposition of the views of the author and his school, the foremost rank of *savans*, the Address is perhaps without its equal in this branch of our scientific literature.

The following are a few of its salient features, but they in no way convey an adequate idea of the Address, which has been printed in full in most of the leading journals:—

Referring to the past history of Bath, the author touches briefly on the ruins of the ancient city, the Aquæ Solis of the Romans, and speaks of its antiquities and of its relatively lower level as compared with modern Bath.

Its mineral waters next command his attention, and he refers to the fact that there has been no material diminution in their temperature (as is also the case in the waters of Aix, Baden, &c.) since the time of the Romans; and, speculating upon the date of their origin, he expresses the belief that "they are only of high antiquity when contrasted with the brief space of human annals;" for, "though their foundations were tens of thousands of years old, they were laid at an era when the Mediterranean was already inhabited by the same species of marine shells as those with which it is now peopled."

The probable cause of hot springs is, according to Sir Charles, a mighty one; their effect equally potent. From their proportionately greater number and higher temperature as we approach the localities in which there are active or extinct volcanoes, he infers that there is a link between the hot spring and the volcano. And after speaking of the large amount of mineral matter conveyed to the surface by such springs (enough, as Professor Ramsay has estimated in the case of those of Bath, to form a solid square column 9 feet in diameter and 140 feet high), and of the immense quantity of nitrogen gas evolved (according to Dr. Daubeny 250 cubic feet per day), he considers the probable effect of such springs to be that of increasing the bulk of the rocks through which they pass, thus giving rise to a mechanical force of expansion capable of uplifting the incumbent crust of the earth; in fact, he constitutes them one of the causes of change in the relative level of land and water.

The Bath springs, Sir Charles Lyell believes, "like most other thermal waters, mark the site of some great convulsion and fracture which took place in the crust of the earth at some former period." "The uppermost part of the rent through which the hot water rises is situated in horizontal strata of Lias and Trias 300 feet thick," the lower passing "through the inclined and broken strata of the Coal measures."

After describing how the water may have passed downward from the surface, dissolving and retaining mineral matter in its course "until it encounters some mass of heated matter," by which it is converted into steam and driven upwards through a fissure, the author touches upon the analysis of the various mineral waters at home and abroad, attributing some of their virtues to the presence in them of what we may call the spectroscopic metals; namely, those traced by means of the spectroscope—of Lithium, Strontium, Rubidium, &c.; and he speaks of a hot spring discovered near Redruth, in Cornwall, in 1839, at a great depth in a copper-mine, in which Professor W. A. Miller has found besides the usual mineral constituents, not only Cæsium, but Lithium, to the extraordinary amount of 1-26th part of its whole solid

contents. Sir Charles believes that the efficacy of the new metals for medicinal purposes will probably soon become manifest, and that they will be produced in large quantities and employed in the cure of diseases "which have hitherto baffled human skill."

After noticing some of the phenomena connected with the gradual decrease of temperature in the water as it rises in hot springs and the minerals with which it is charged, he expresses the belief that there is some relationship "between the action of thermal waters and the filling of rents with metallic ores," suggesting that the component elements of the ores may first be held in a state of solution or sublimation in the intensely hot water below, and as this cools be deposited in the fissures.

Another geological phenomenon in which he believes hot springs to play a prominent part is metamorphism, the conversion of deposited strata, many of which once were full of organic remains, into crystalline rocks. Recent experiments and observations have taught geologists that such changes have been the result, not of heat alone, but of heat and water combined, of "hydrothermal" action; that such rocks have been converted, not in the "dry way," which would necessitate an enormous amount of heat, but in the "wet way," "a process requiring a far less intense degree of heat."

Adducing as evidence the experiments of Senarmont, Dobree, Sorby, Sterry Hunt, and other reliable observers, as well as that afforded by the action of thermal springs during the historic period, Sir Charles believes that in the course of ages whole mountain masses may have become thus converted, by means of water permeating through them charged with carbonic and hydrofluoric acids. Whilst, however, he is disposed to substitute for intense heat a longer period of time for the formation of crystalline rocks, Sir Charles still holds that the temperature of the mass below, with which the water is mixed up must be extremely high, and referring to the experiments of Bunsen on the Great Geyser of Iceland, he mentions that at a depth of only 74 feet water in a state of rest possesses a temperature of 248° Fahr.; the temperature then at a depth of a couple of thousand feet is probably intense, as the erupted glowing lava of volcanoes testifies.

To account for this increasing heat as we descend into the earth is at present impossible, or, as Sir Charles observes, "the exact nature of the chemical changes which hydrothermal action may effect in the earth's interior will long remain obscure to us, because the regions where they take place are inaccessible to man; but the manner in which volcanoes have shifted their position throughout a vast series of geological epochs—becoming extinct in one region and breaking out in another—may perhaps explain the increase of heat as we descend towards the interior, without the necessity of our appealing to an original central heat or the igneous fluidity of the earth's nucleus."

Quitting then the subject of hot springs, the President adverts to the changes which, in past ages, have taken place in the land-level of England, and refers to the time when "the Cotswold Hills, at the foot of which this city" (Bath) "is built, formed one of the numerous islands in an archipelago into which England, Ireland, and Scotland

were then divided;" and when the sea flowed over Moel Tryfaen, a hill near the Menai Straits, where fossil marine shells have been found at a height of 1,360 feet above the present sea level.

Passing then to the question of the changes in temperature which must have taken place in England, in common with the whole of central Europe (and speaking chiefly in relation to the Glacial period), he attributes these changes in part to a general alteration in the height of the seas, continents, and mountain ranges; and shows that at one time the Sahara, or great Desert of Africa, must have been under water; the high lands of Barbary, &c., separated from the rest of Africa by a sea; and that there has probably been a connection between Barbary and Southern Europe. The gradual melting away of the Swiss glaciers, Sir Charles attributes to some extent to the Sirocco, or, as the peasants call it, "the Föhn," which hot wind crosses over from Africa; and showing that a cessation of this warm blast, for a brief period only, causes the ice to accumulate perceptibly even in our day, he asks, "What mighty effects we may not imagine the submergence of the Sahara to have produced in adding to the size of Alpine glaciers?" or as Escher* argues, "If the Sahara was a sea in post-tertiary times, we may understand why the Alpine glaciers formerly attained such gigantic dimensions, and why they have left moraines of such magnitude on the plains of Northern Italy and the lower country of Switzerland."

"The more," says Sir Charles, "we study and comprehend the geographical changes of the Glacial period, and the migrations of animals and plants to which it gave rise, the higher our conceptions are raised of the duration of that subdivision of time, which, though vast when measured by the succession of events comprised in it, was brief if estimated by the ordinary rules of geological classification."

It is unnecessary to follow the President through the review which followed, of the story of man's antiquity as it is at present related by Archæologists and Palæontologists; suffice it to say that he traced him through the "Age of Bronze" to the Stone period, when "flint implements" were almost his only weapons, and when his bones lay side by side with the extinct quadrupeds of Europe—the "Elephant, Rhinoceros, Bear, Tiger, and Hyena."

After referring humorously to the reluctance with which some students of Geology bring themselves to consider the long ages that modern science is disposed to attribute to the Glacial and Post-glacial periods, Sir Charles concludes his Address with a few observations upon two questions at present agitating the scientific world: "First, as to whether there has been a continuous succession of events in the organic and inorganic worlds, uninterrupted by violent and general catastrophes; and secondly, whether clear evidence can be obtained of a period antecedent to the creation of organic beings on earth."

In regard to the first point, Sir Charles here speaks with great caution, but we think it may be gathered from his remarks that he considers the "convulsionist" theory to be dying out and giving place

* Escher von der Linth.

to a doctrine in Geology analogous to that of Mr. Darwin in Natural History; with reference to the second, he notices the observations of Dr. Dawson, of Montreal, upon the fossils found in the Laurentian rocks of Canada,* which rocks "are of as old a date as any of the formations named azoic in Europe, if not older, so that they preceded in date rocks once supposed to have been formed before any organic beings had been created;" and Sir Charles expresses the opinion that these observations of Dr. Dawson have demonstrated the theories founded "in Europe on mere negative evidence" to be "altogether delusive." Throughout the whole of this admirable Address Sir Charles seems to have taken especial care, as we think wisely, not to commit himself definitely to any of the numerous theories which at present agitate the Geological world.

In seconding a vote of thanks to the President, Sir Roderick Murchison, who differs from Sir Charles Lyell on some material questions in Geology, nevertheless made a statement which it may be as well to transfer to these pages, as there may perhaps be here and there a few persons who entertain the belief that scientific men are never agreed on any subject which interferes with *their* preconceived views. Such persons will find that, on certain geological doctrines which they bring their minds to consider with great reluctance as being opposed to those of tradition, there is now no difference of opinion whatever. "Let me assure this assembly," said Sir Roderick, "that in all the grand leading *data* on which the history of geology is based we are completely united, and whether it be in recording the regular succession of formations from the oldest to the youngest, the progression from lower to higher types of life, the enormously long periods which must have elapsed in the formation of deposits and their frequent change into crystalline conditions by that metamorphism which he has so skilfully expounded; and lastly, in the evidences he has brought together to show that man must have coexisted with some of the great fossil mammalia. On all these subjects I hold the same opinions as himself; and I have ventured to make this explanation, because it seems to me essential that the public should not run away with the idea that because geologists occasionally disagree on points of theory, that there exists among them any divergence of opinion as to the great foundation stones on which their science has been reared."

Physical Science. (Section A.)

Phillips on the Physical Aspect of the Sun.—Miller and Huggins on the Spectra of the Heavenly Bodies.—Claudet on Photosculpture.

Amongst the large number of papers brought before this Section only a few are of general interest. The greater number are mathematical, and of the physical papers not many will bear the condensation necessary for a report in our pages. We shall therefore omit all reference to such as cannot well be given in abstract.

* 'Quarterly Journal of Science,' vol. i. p. 476.

Some valuable remarks were made by Professor Phillips on the "Physical Aspect of the Sun." In this examination he had been much aided by Cook's Solar Eyepiece, by means of which he was enabled to observe highly luminous bodies. He wished to draw attention to two phenomena—the faculæ and the porosity; he had observed the former as distinctly as the clouds in our own sky. These luminous places were shaded as clouds are with us, and as the Alps appeared at some 50 miles distance. Some of these faculæ were ranges of 40,000 miles long and 40 miles high. With regard to the question of porosity, all that he had observed was an irregular mottled surface between the luminous bands which he had called faculæ, but these markings might be compared to anything, assuming accidental shapes, and formed no definite figure.

On Monday, Dr. Miller, on behalf of himself and Mr. Huggins, read a most interesting paper, "On the Spectra of some of the Heavenly Bodies." The paper directed attention to three leading points, *viz.* facts relating to the planetary spectra, others relative to the spectra of double stars, and some data concerning the spectra of nebulæ. The presence of metals, as evidenced in the case of the light of the planets and some of the heavenly bodies, proved them to be composed of terrestrial substances, whilst the nebulæ were as evidently bodies of gaseous vapour, the character of their light showing that there was no solid matter in them. In the discussion which followed the reading of this paper, Mr. Balfour Stewart said that the remarks on the planetary nebulæ were most important, in showing quite a different constitution of these nebulæ than had been hitherto accepted.

Mr. A. Claudet read a long and valuable paper, "On Photosculpture," the invention of M. Willeme, a French sculptor. This gentleman saw that if he had photographs of many profiles of his sitter taken at the same moment by a number of cameras placed around, he might alternately and consecutively correct his model by comparing the profile outline of each photograph with the corresponding outline of the model. But it soon naturally occurred to him that, instead of correcting his model when nearly completed, he had better work with the pantagraph upon the rough block of clay, and cut it out gradually all round by following one after the other the outline of each of the photographs. Now, supposing he had twenty-four photographs representing the sitter in as many points of view all taken at once, he had but to turn the block of clay after every operation 1-24th round, and to cut out the next profile, and repeat this until the block had completed its entire revolution, and the clay would be transformed into a perfectly solid figure of the twenty-four photographs,—the statue or the bust was made, and only required the finishing touches to be given to it by the artist, who would perform the last operation and would exercise his skill in communicating to the model all the refinement with which, as a sculptor merely, he could have endowed it. Mr. Claudet said, in conclusion, that he thought he could not better illustrate the process of photosculpture than by executing the bust of the President, Sir Charles Lyell. The photographs were taken on the 16th of August;

the machine had done the work; the sculptor had given the finishing touches to the model; and the bust complete, a most striking likeness, was then exhibited to the meeting.

Chemistry. (Section B.)

President's Address.—Daubeny on the Bath Thermal Waters.—Report of the Gun-cotton Committee.—Miller on Wheal Clifford Hot Spring.—King on the Frescoes in the House of Commons.—Calvert on the Extraction of Gold from Auriferous Rocks.—Field on Tin Ore, &c.—Spence on Copper Smelting.—Papers by Herapath, Catton, Paul, Phipson, and Machattie.

The proceedings of the Chemical Section were opened by the President, Dr. Odling, F.R.S., who, in a short but eloquent address, placed before his audience a comprehensive view of the reformation which, within the last dozen years or so, has been effected in the opinions concerning the combining proportions of the elementary bodies and the molecular weights of their most important compounds. The development of the matured views of chemical philosophy which now prevail must, the President said, be traced to Gerhardt's division of volatile bodies into a majority whose recognized molecules corresponded with four volumes of vapour, and a minority whose recognized molecules corresponded respectively with but two volumes of vapour; and from Gerhardt and Laurent's proposal to double the molecular weights of these last, so as to make the molecules of all volatile bodies correspond each with four volumes of vapour. Prior to the time of Gerhardt, the selection of molecular weights for different bodies, elementary and compound, had been almost a matter of hazard. Relying conjointly upon physical and chemical phenomena, he first established definite principles of selection by pointing out the considerations upon which the determination of atomic weights must logically depend. He thus established his classification of the non-metallic elements into—mon-hydrides, represented by chlorine; di-hydrides, represented by oxygen; ter-hydrides, represented by nitrogen; &c.: and relying upon the same principles, later chemists have given to his method a development and unity which have secured for the new system the impregnable and acknowledged position which it at present occupies. Dr. Odling then made a passing allusion to the researches of Professor Kopp on specific heat, and expressed the obligations chemists were under to him for the great additions he had made to this subject; and then proceeded to the oft-debated question of chemical notation. This is at present in anything but a satisfactory state. The sign of addition, so frequently used to express the fine idea of chemical combination, is about the last one would deliberately select for such a purpose. The placing of symbols in contiguity with or without the introduction of a point between them is far preferable; but here, as pointed out by Sir John Herschel, we violate the ordinary algebraic understanding, which assigns very different numerical values to the expressions xy and

$x + y$ respectively. The speaker said that, for some years past, Sir Benjamin Brodie had been engaged in working out a new and strictly philosophical system of chemical notation by means of actual formulæ, instead of mere symbols; and Dr. Odling felt that he only expressed the general wish of the Section when he asked Sir Benjamin Brodie not to postpone the publication of his views for a longer time than was absolutely necessary. It becomes every day more and more important to render the present system of symbolic notation more precise in its meaning and consistent in its application. Many of its incongruities belong to the very lowest order of convention; such, for example, as the custom of distinguishing between the so-called mineral and organic compounds; one particular sequence of symbols being used habitually in representing compounds of carbon, and an entirely different sequence of symbols in representing the more or less analogous compounds of all other elements. It is high time that such relics of the ancient superstition, that organic and mineral chemistry are essentially different from one another, should be done away with. After a brief glance at synthetic chemistry, and isomerism, which was designated the chemical problem of the day, the President concluded by referring to the healthier state of mind in which now perhaps more than ever the first principles of chemical philosophy are explored. Speculation, indeed, is not less rife and scarcely less esteemed than formerly, but it is now seldom or never mistaken for ascertained truth. Scepticism, indeed, still prevails, but it is no longer the barren scepticism of contentment, but the fertile scepticism which aspires to greater and greater certainty of knowledge.

Dr. Daubeny read a most exhaustive paper, "On the Bath Thermal Waters." Under the impression that some of the benefit derived from the use of these waters might be due to the presence of some hitherto undiscovered principle latent in the waters, the lecturer had lately concentrated by evaporation considerable quantities of the water, and tested the residuum, with the view of ascertaining whether, besides the ingredients determined by previous analysts to exist in it, certain other principles might not also be present at least in infinitesimal quantities. He could, however, discover no traces of Fluorine, of Baryta, of Strontia, or of Lithia, although the very delicate method of spectrum analysis was employed to detect their presence. Phosphoric acid and bromine were, however, found to be present. The quantity of gas disengaged from the King's Bath averaged 222 cubic feet in twenty-four hours, and the same phenomenon was observed at least a century and a half ago, showing that the disengagement of gas was by no means a recent occurrence, or one depending on merely adventitious causes. The gas on analysis was found to consist chiefly of nitrogen. If, therefore, the gas emitted were derived from atmospheric air, the latter must have parted with four-fifths of its oxygen before it reached the surface of the earth. This phenomenon is so much the more important, inasmuch as it is common to all natural hot-springs. The lecturer passed in review the different explanations which had been given to account for the origin of this gas, and gave it as his opinion

that there was ample reason to infer that the evolution of nitrogen gas when in great excess of the oxygen was essentially connected with that igneous action which is going on in the interior of the earth, and that it was met with in thermal waters only because the latter derived their heat from the same chemical operations which give rise to the phenomena of volcanoes. We are thus compelled to assume that some process of oxidation is going on in the locality, such as should bring about the absorption of the oxygen present in the air which penetrates to these depths. The author then entered into a most interesting discussion as to the cause of thermal springs and volcanoes; the latter phenomena especially resembling those which would occur if water and air were brought into contact with metallic bases possessing a strong affinity for oxygen; and concluded by suggesting that the surplus heat from the springs, which was at present allowed to be wasted in the river, should be utilized by allowing the water to pass through coils of pipes let into the ground a few feet below the surface, so as to communicate its heat to the soil within a given area. With no further expense than this, such an arrangement would secure to the plot of ground placed under the influence of this adventitious temperature a bottom heat sufficient for the growth of early vegetables and for the cultivation of tender exotics; whilst if the waters were in the first instance emptied into a small pond, and afterwards transmitted from thence by means of a coil of pipes gradually embracing a larger circle as they extended, nothing but the protection of an external covering of glass would be required for the cultivation of the gigantic Victoria Regia and other tropical water-lilies; whilst the borders of the pond would at least secure to the inhabitants of Bath the enjoyment of many of the trees and shrubs of warmer countries in the open ground of the garden, and a participation in a genial atmosphere during their most rigorous seasons.

The Gun-cotton Committee laid their second report before the members of this Section. This was merely a formal document relating the circumstances which have taken the matter out of their hands. The Government have appointed a committee to investigate the subject in all its bearings, and have placed on it several members of the British Association Committee. At the close of the report, Professor Abel said that his researches, made on behalf of the Government, were of a satisfactory character, gun-cotton possessing a great superiority over gunpowder both in the simplicity and safety of its manufacture.

Dr. Miller then read a paper, "On the Wheal Clifford Hot Spring, near Redruth, Cornwall," in which he had detected so large a quantity of Lithium that it could not fail to become an economical and abundant source of that rare alkaline metal.

Mr. A. Poole King read a paper, "On the Premature Decay of the Frescoes in the Houses of Parliament," in which he predicted the rapid destruction of these frescoes if the apartment were allowed to remain cold and damp. The moisture would condense in drops on its surface, and be absorbed. These drops would dissolve whatever trace

of sulphate of soda existed in the plaster or in the mortar of the wall. The salt would aggregate together, then form ice-like crystals; would leave the plaster, and show itself in a bloom on the surface of the fresco, to be re-dissolved by the first moisture which came over it, and then be re-absorbed again, till at last it would aggregate into blotches, and the destruction would be complete. To preserve the fresco, the author recommended that the robing-room should always be kept dry and warm.

Dr. C. Calvert's paper, "On a New Method of Extracting Gold from Auriferous Rocks," described a method which presented the advantages of not only dispensing with the costly use of mercury, but also of extracting the silver and copper which the ore might contain. The agent employed was nascent chlorine, evolved from a mixture of salt and binoxide of manganese ground up with the auriferous quartz in the proportion of two or three per cent. When sulphuric acid was added the liberated chlorine would attack the gold, and upon allowing water to percolate through the mass it would dissolve out all the gold (as well as the copper and silver), which could then be easily precipitated in the metallic state. This process was said to yield good results, even when working upon a very poor quartz.

Mr. F. Field then described a new ore of tin, and appended to it a few remarks on the state of mineralogy in this country. Referring to the high price and scarcityof bismuth, he said that if search were made in Cornwall there would be no difficulty in getting it; but some persons seemed to have gone fossil mad, and neglected the really valuable minerals, which could be found in almost every county.

These remarks were entirely corroborated by Mr. Salmon and Professor Tenant; and the latter speaker instanced a case in Australia, where a black substance which was at first thrown away in the rush after gold was afterwards found to be tin ore, and was sold for 40*l.* a ton.

An important paper was then read by Mr. Spence, "On Copper Smelting and the Means of Economizing the Sulphur evolved in the Operation." He said he had for many years directed his attention to the subject of economizing the sulphur in copper ores. He had erected furnaces in which small ores could be calcined with little expenditure of fuel and labour, and this enabled him to send all the sulphur so eliminated into the vitriol chambers as sulphurous acid gas. The amount of sulphur wasted in copper-smelting, and which could be economized by the use of such calcining furnaces as he had erected was something enormous. It had been estimated at 70,000 tons per annum, which at the present price of sulphur would be worth 455,000*l.*

A paper by Dr. M. B. Herapath, "On a New Method of Detecting Arsenic, Antimony, Sulphur, and Phosphorus by their Hydrogen Compounds when in Mixed Gases," entering into special analytical details, is of too limited an interest to be transferred to our report, and from the nature of the subject it cannot be given in abstract. The same may be said of Mr. Catton's papers "On the Direct Conversion of

Acetic Acid into Butyric and Caproic Acids," and "On the Molecular Constitution of Carbon Compounds."

These were followed by one by Dr. Paul, "On Paraffin Oil," in which he said that whilst oils lighter than water were quite different from those in gas-tar, the oils heavier than water were very similar, if not identical, with those in gas-tar; and one by Dr. Roscoe, in which he announced that by means of the spectroscope he had detected strontium and lithium in the Bath hot springs in addition to the other well-known constituents.

Dr. Phipson next described some black stones which fell from the atmosphere at Birmingham, in 1858. Analysis showed that they were not aërolites, but small fragments of basaltic rock, similar to that which existed a few leagues from Birmingham. He believed that the stones had been carried to Birmingham by a waterspout. The same author also had a paper, "On the Medicinal Muds of the Island of Ischia." It was in this island and elsewhere customary to plunge the body into muds of this kind as a means of restoring health. They were composed of a volcanic sand, rendered muddy by water and a certain quantity of vegetable *débris*. He had no doubt that the water in its natural state was strongly impregnated with sulphuretted hydrogen, and it was to this agent principally that the medicinal properties were to be ascribed.

A paper by Dr. A. T. Machattie, "On the Detection of Poisons by Dialysis," was next read. This constituted an important contribution to toxicological chemistry, but would be too long to be given at full length in our pages, whilst an abstract would be unintelligible.

One or two other papers of interest will be referred to in the Chemical Chronicle of our next number.

Geology. (Section C.)

Phillips on a Cranium of the Stone Period.—Sanders on Bristol Coal Fields.—Sorby on Metallic Meteorites.—Browne on Ice Caves.—Moore on the Palæontology of Frome.—Stoddart on Geology of Clifton.—Randell on Geology of Bath.—Tristram on Geology of Palestine.

Among the early communications in this Section was one by the President, Professor Phillips, who produced a fragment of a human cranium, taken out *by himself* from the lower strata of one of those singular heaps of accumulated *débris* known on the shores of the Lake of Geneva, laid bare by a railway cutting some time ago, and then described by M. Morlot. In certain parts of this kind of delta, produced on dry land and with great regularity from the annual accession of fresh material, objects were found marking pretty clearly a positive date. Thus, the Roman occupation of Switzerland, which occupied on the whole about 700 years, yielded a few fragments by which it is

identified. The bronze period was represented by another group; the period of occupation since the Romans by another; and there is also a stone period earlier than the bronze. This latter is probably contemporaneous with the period of the lake villages, estimated from this source of independent evidence at about 6,500 years old. The fossil was found in this part. There is an element of doubt involved in the absence of certainty as to the limits of the deposit during the Roman occupation of the country.

When this matter was debated, there were several communications bearing on the same subject, and an interesting discussion arose on the antiquity of the human race. The most remarkable feature was the unanimity of the speakers, and the perfect and manifest sympathy exhibited by a very large audience, who kept together in the Section room without flinching from 11 till 4 o'clock. The absence of Dr. Falconer and Mr. Busk, who have just started for Gibraltar, rendered any allusion to the newly-discovered human remains from that quarter undesirable.

Another important communication was the account given by Mr. Sanders of a most admirable and detailed map of the Bristol coal-fields, prepared from parish maps, on a scale of four inches to a mile, independently of the Government survey. In the course of fifteen minutes Mr. Sanders gave an outline of the intelligent and indefatigable labour of a quarter of a century. The manner was worthy of the matter.

Mr. Sorby directed attention to the fact that in metallic meteorites, iron (s. g. 7·8) and olivine (s. g. 3·4) appeared to have been in fusion together, the olivine being left diffused through the iron after cooling. He pointed out that this was impossible on or near the earth's surface, owing to the difference of the specific gravities; and suggested, as an explanation, that the fusion and cooling might either have taken place in the metallic centre of small independent bodies, where the specific gravity was *nil*, the meteorites being fragments of such bodies entering subsequently within the earth's attraction, or that each meteorite had been itself a separate small body cooled in space.

A new and original communication was that of the Rev. G. F. Browne, being an account of several ice-caves or *glacières*, some of them newly discovered, but others already known and described, in Dauphiné, Savoy, and parts of Switzerland. The enormous accumulations of ice, exhibiting in some caves a thickness of 180 feet, the rate of increase of the ice deposit from year to year, the condition and temperature of the ice in summer and winter, and the fact that while some caves at very moderate elevations are full of ice, others apparently under similar conditions and at much greater elevations are free, seem to exclude by turns all the theories that have been suggested. The texture of the cave-ice which occurs in groups of crystals, forming prisms in some parts of the mass, was the subject of a separate communication to the Chemical Section, but complicated the geological problem. It will be necessary to pay greater attention to this curious subject.

Very interesting local communications were made by Mr. Charles Moore and Mr. W. Stoddart. The former alluded to the extraordinary abundance of fossils in the clay near Frome, where more than a million organisms, including 29 mammalian types and many reptilia, were obtained by him from a single cart-load of the material. From the Rhætic beds also Mr. Moore obtained 70,000 teeth of one kind of fossil alone. Mr. Stoddart endeavoured to prove that the dividing line between the Carboniferous and Devonian rocks lies below and not above certain highly-fossiliferous beds at Clifton, which in Ireland have been regarded as Devonian, but are there less rich in fossils. The Marwood sandstone, Coomhola grits, and some other beds, are the Irish representatives, and are largely developed in the south-west of that country. At Clifton, a thin limestone among marls is loaded with incredible numbers of minute organisms, easily separated from the matrix, as the fossils are insoluble in dilute acid, which removes the limestone completely and rapidly. From one pound weight were obtained 1,600,000 perfect fossils, besides fragments and *débris*.

A valuable local memoir was read by Mr. J. Randell on the important beds of building-stone quarried near Bath. The export of these stones from the quarries around Bath exceeds 100,000 tons per annum, and they are conveyed to great distances. Mr. Randell described very accurately their geological position, which he stated to be perfectly definite in the oolitic series. He remarked that the beds occasionally thin out as if lenticular, but they are always under a capping of harder, rougher, and less valuable stone. They die away to the east and south-east. The dip is small, varying generally from one in forty to one in sixty. The thickness of the best stone is from 12 ft. to 25 ft. Above it are 25 to 50 feet of Upper Rag not worked to send away, tough, shelly, and brownish in colour. Below are from 150 to 200 feet of Lower Rag, not always coarse, but apt to decompose on exposure. Mr. Randell then described the method of working in the best quarries. After the first block has been obtained from under the rag, the stone is all sawn, avoiding waste from blasting and wedging. The stone is generally got in the same manner as coal in stalls whose width depends on the goodness of the roof. There is no waste.

A discussion arose on this paper. Professor Phillips alluded to the stone selected by the Romans as having stood better than that now got. Professor Ansted pointed out that the stone, like others, stood much better in a building when it had been first thoroughly dried and hardened in the air. Mr. Ethridge spoke to the accuracy of Mr. Randell's sections.

Mr. Tristram read several interesting communications on the Geology of Palestine and the adjacent parts of Asia Minor. He exhibited fragments of a bone breccia with flint flakes, which Mr. Evans was prepared to assert must certainly have been of human manufacture, and brought from a distance. The age of the breccia was not however clear. Mr. Tristram also exhibited a series of very curious fossils from a limestone of the cretaceous period. Among

them were some Ammonites resembling Ceratites, bivalve shells resembling liassic and triassic species of Pholadomya, and others having similar peculiarities. Some of these have lately been found in Africa.

Zoology and Botany. (Section D.)

President's Address.—Galton on Domestication of Animals.—Gibb on the Larynx of the Negro.—Crisp on the Anatomy of the Quadrumana.—Tristram on the Ornithology of Palestine.—Cobbold on Entozoa.—Davy on Salmonidæ.—Buckland on the Oyster.—Lankester on the Earthworm.

In his address, the President, Dr. J. E. Gray, F.R.S., entered in the first place into an inquiry as to the best plan to be pursued to make museums of natural history most useful both to the general public and the scientific student. For the former he considered that a collection of the more interesting objects was required, so as to afford the greatest possible amount of information in a moderate space, and, instead of crowding together a number of specimens of a given genus on the shelves, characteristic specimens should be selected and distinctly labelled, and the purpose for which it was prepared and exhibited should be specified; the economic uses to which it is applied should also be given. For the scientific student he considered that instead of stuffing and mounting the specimens, they could be much more efficiently examined by properly arranging them in drawers and boxes, which would at the same time ensure economy of space.

He then entered into the question of the acclimatization of animals. This term has been employed to express the domestication of wild animals, the introduction of the domestic animals of one country into another, and the cultivation of fishes by the restocking of rivers, ponds, &c., already exhausted. He did not think that any of the wild animals which it was proposed to domesticate could compete in feeding and fattening qualities with our present races of domestic cattle. And though Asiatics have been able to draw largely upon the wild animals around them, yet these are but little suited for our northern climate. He pointed out that it would be advisable to try, in attempting to introduce new domestic animals into our Colonies, if some of the domestic races of Asia or Africa might not be better adapted to their climates than many European breeds. He did not regard very hopefully the attempt to introduce salmon into the Australian rivers, for during a considerable part of each year they are reduced to stagnant pools. The deep rapid rivers of Tasmania he looked on as much more promising. The Acclimatization Society of Australia ought rather to strive for the introduction of the gouramy, or some other edible fish of the countries nearer to and more resembling their own.

A paper of considerable interest was read by Mr. Francis Galton, F.R.S., entitled "First Steps towards the Domestication of Animals."

In it the author contended that the following conditions were required for wild animals to become domesticated. 1st. They should be hardy. 2nd. They should have an inborn liking for man. 3rd. They should be comfort loving. 4th. They should be found useful to the savages. 5th. They should breed freely. 6th. They should be gregarious. The first domestication of animals was due to a vast number of half-unconscious attempts made through the course of ages, and at length, after slow degrees and many relapses, and continued selection, the several domestic breeds now existing became firmly established.

Dr. Gibb read a paper, "On the Larynx of the Negro," in which he stated that the essential point of difference between this organ in the white man and the Negro consisted in the invariable presence of the cartilages of Wrisberg, in the oblique or shelving position of the true vocal cords, and the pendent position of the ventricles of Morgagni in the latter. His observations were based on the examination of the larynx in 500 whites and 58 blacks.

A paper was contributed by Dr. Crisp, "On the Anatomy of the Quadrumana, with a Comparative Estimate of the Intelligence of the Apes and Monkeys." The author in the first place described a method of displaying the comparative anatomy of an animal by means of plaster and wax casts of the most important parts, and showing these alongside of the skeleton and stuffed skin. He then adduced many facts in the anatomy of the Quadrumana, and came to the following conclusions:—1st. That the anthropoid apes, both anatomically and in reference to their amount of intelligence, are not entitled to the elevated position in which they have been placed by some anatomists. 2nd. That the line of demarcation between man and these brutes is so wide and clearly defined as to entitle the human family, as maintained by Blumenbach, Cuvier, and others, to a separate and exclusive division in the animal scale.

The Rev. H. B. Tristram then read a paper, "On the Ornithology of Palestine and the Peculiarities of the Jordan Valley." The author, during a residence there last year, obtained fourteen different kinds of chats, and some birds like the golden plover and the blackwing. Various new species, or new to that locality, were described; amongst these were specimens of the following new and hitherto undescribed species:—The Ceylonese eagle-owl, only hitherto known in South India and China; Gurney's sparrow-hawk, peculiar to Palestine; the Peregrine falcon, on the coast; the Lanner falcon, on the highlands; and the Saker falcon, the largest of all, in the interior; a new species of night-jar, confined exclusively to the Dead Sea; the Galilean swift, confined to the Jordan Valley; the great Alpine swift, and many other species which our limited space will not allow us to name.

Dr. Cobbold, F.R.S., read a paper, "On the Development and Migrations of the Entozoa," in which he related a number of experiments made on the mode of propagation of flukes, tapeworms, round-worms, or their larvæ. He pointed out that the larvæ of the smallest tape-

worm yet known were the sole cause of the fatal echinococcus disease of Iceland.

Dr. John Davy read a paper, "On the Salmonidæ, chiefly relating to their Generative Functions." His observations were in part made on the parr of the sea-trout (Salmo trutta), and the object of his inquiry was to ascertain if it, like the parr of the salmon, exercises the generative functions. He concluded that the probabilities were in favour of this view. In the young of the brown trout he has never found the testes more than rudimentary. He does not believe that the sea-trout breeds on its return from the sea into the rivers, as is the case with the salmon, for the ovaries he has examined at this period of the growth of the fish are in little more than a rudimentary state. He thought that with regard to the salmon, sea-trout, common trout, and charr, the evidence was rather in favour of them breeding only in alternate years, or at least not in successive years.

Mr. Frank Buckland, "On the Natural History of the Oyster," in which he related the attempts that had recently been made to promote the artificial cultivation of oysters. He pointed out that this year there had been a failure in the oyster spat, and submitted that the investigation into the cause of this failure was a proper subject of inquiry for scientific men.

Mr. E. R. Lankester read a paper, "On Certain Points in the Anatomy of the Earthworm." The parts to which he directed attention were, firstly, three undescribed pairs of glands connected with the œsophagus; and secondly, the reproductive system. The glands are situated in the twelfth and thirteenth segments of the body. The most anterior pair lie in the twelfth segment; they contain a dense crystalline mass. The two posterior pairs lie in the thirteenth segment; they contain a milky fluid. The author calls them œsophageal glands from their relation to that tube. His observations on the reproductive system coincided almost entirely with those of Dr. Hering, and, in all essential details, with M. d'Udekem.

Physiology. (Sub-section D.)

President's Address.—Turner on Nutrient Arteries for the Lungs.—Foster on Muscular Irritability.—Herapath on Indigo in Pus.—Davy on the Temperature of the Sexes.—Gibb on Action of Bromides of Lithium, Zinc, and Lead.—Hayden on Fat and Sugar as Respiratory Food.—Smith on the Nutritive Principles of Food.

The introductory address by the President, Dr. Edward Smith, F.R.S., consisted of an elaborate and highly interesting report, "On the Present State of the Dietary Question." He reviewed the dietaries of the various prisons, which he considered to stand at present in a very unsatisfactory state; the dietaries of hospitals, schools, and other educational establishments. Referring to "Bantingism," he pointed out that the system of reduction was in numerous cases quite inapplicable.

He then showed that the coarse foods, once so largely employed by the labouring classes, had gone out of use because the labourer had now better wages, the taste was not so agreeable as the finer foods, and they could only be used intermittingly. The nature of the diet employed in various districts of the country was discussed, and the question of the digestibility of food was considered under the various heads of kind, quantity, and conditions under which it acts. An interesting discussion followed, in which Professors Acland and Rolleston, Sir John Richardson, the Bishop of Bath and Wells, and other gentlemen took a part.

"On a Supplementary System of Nutrient Arteries for the Lungs." By Wm. Turner, M.B., F.R.S.E. An arterial plexus was described on the side of the pericardium beneath the mediastinal pleura. It was formed by the junction of the pericardiac, mediastinal, and phrenic branches of the internal mammary artery with each other and with numerous fine branches from the trunks of the intercostal arteries. From it a number of slender thread-like arteries passed to the lung, some in front of its root, others behind, and others between the layers of the ligamentum latum pulmonis. Some of these arteries were distributed in the substance of the lung; others, on its surface beneath the pulmonic pleura. Through the agency of this plexus, an arterial communication is established between the blood vessels of the lung and the arteries which supply the wall of the chest with blood.

Report by Dr. Foster, "On Muscular Irritability." The conclusions drawn from the statements made by numerous experimenters were as follow:—That the urari experiments are inconclusive, because it is not proved that the ultimate nerve branches are affected like the penultimate. That Eckhard's anelectronic experiment is inconclusive, because irritability is by it only lowered, not entirely suspended. That the series of chemical stimuli experiments by Wittich, Kühne, &c., are inconclusive, for the same reason as the urari series; but that the fact that chemical stimulation will take place during the anelectronic effect of the constant current shows, either the contractile tissue is of itself irritable, or that no confidence can be placed in Eckhard's arguments, and that one experiment of Kühne's on that point is almost an experimentum crucis. That, on the whole, the evidence of the above series is decidedly in favour of the existence of muscular irritability. That the experiments and observations of Kühne, Auerbach, and Aeby show that the idio-muscular contractions of Schiff are in reality ordinary contractions in an abortive state and not a special form of contraction; and that the same observations offer connecting links between the oscillatory contractions witnessed by Mr. Bowman, and shown by him to be clearly not due to nervous action, and so afford proof that in a muscular contraction there are two things to be considered — the putting certain molecules in movement, and the communication of that movement from those molecules with greater or less rapidity to all the rest of the fibre; and that since the first movement may commence anywhere, the whole fibre must be called irritable.

"On the Presence of Indigo in Purulent Discharges." Dr. Hera-

path examined pus presenting a greenish-blue colour. He found that the fluid lost its colour on being corked up in a close bottle, but reassumed the blue colour on exposure to air. He supposed that this was due to the presence of a colourless material analogous to Indigo and the action of oxygen on it. He obtained crystals from the pus in six-sided plates, and aciculi of a deep-blue colour when sublimed. Other tests were employed which furnished evidence of the presence of Indigo Blue in the pus.

Dr. John Davy, "On the Temperature of the Sexes." Dr. Davy, from observations made in the Tropics and in England, supported the view that the temperature of the male is greater than that of the female.

Dr. G. D. Gibb read a note, "On the Action of the Bromides of Lithium, Zinc, and Lead." The first of these was prepared with the view of treating gout and rheumatism; in small doses it acts as a tonic, gentle stimulant, and sometimes as a diuretic. The Bromide of Zinc relieved impaired nervous power, whilst the Salt of Lead acted as a soothing and cool local agent in some inflamed states of the mucous membrane.

Dr. Hayden read a paper, "On the Relative and Special Applications of Fat and Sugar as Respiratory Food." He believed that fat and sugar possessed different values as food; that they underwent different transformations, during which they subserved distinct purposes of the economy; that the period of their retention in the body is the same; that they are not mutually convertible; but that ultimately they pass out of the body under the common form of carbonic acid and water, and are jointly concerned in the production of animal heat. He considered that fat, being an assimilable substance, can under no circumstances be applied to the maintenance of animal heat before undergoing the twofold process of constructive and destructive assimilation, but that amylo-saccharine substances are immediately and directly passed off from the blood, and are never assimilated in the proper sense of the term. The general conclusions he had arrived at from his experiments were as follows:—The amount of fat deposited in the body is regulated by the absolute and relative quantity of oleaginous and saccharine matter in the food taken; both substances taken in a large quantity, cause excessive deposits of fat. If the fat taken be in defect, even though the sugar be in excess, no increase in the deposit of fat takes place, but rather a decrease, obviously in consequence of ordinary molecular absorption, to which the adipose, in common with other tissues, is subject, not being counterbalanced by assimilation. If the fat taken be in excess, whilst the sugar is insufficient to meet the immediate wants of the respiratory function, still the deposit of fat may not undergo increase, but the contrary, apparently because a portion of that already deposited must undergo reabsorption into the blood for the purpose of supplying heat. Fat is, therefore, as a heat-producing substance, only supplemental of sugar, which is the ordinary *pabulum* of respiration. Saliva, like gastric juice, is secreted in quantity strictly proportioned to the immediate wants of the system, and quite irrespec-

tively of the absolute quantity of food taken; a certain proportion of the starch of the food, varying according to the quantity taken and the necessity of respiration, escapes the converting action of the saliva, and is stored up in the liver. This liver-starch is being taken constantly back into the blood to supplement the respiratory elements of the food, and in the blood is converted into sugar, probably next into lactic, and finally into carbonic acid. Hence the presence of sugar, normally, in small proportion in the blood of the right side of the heart, hence, likewise, its presence in the right side of the heart of animals fed exclusively upon meat, in whose portal blood not a trace of sugar is discoverable.

In three papers Dr. Edward Smith entered into a very elaborate inquiry into the nutritive principles of food; the proportions in which they entered into the different kinds of food; and the most useful combinations of different articles of diet. He showed that there were four methods in use for estimating the nutritive value of food. 1st. The weight of the food. 2nd. The nitrogenous and carboniferous elements in it. 3rd. The nitrogenous food, carbon and hydrogen (reckoned as carbon) in food. 4th. The nitrogen and carbon in food. The mode of determining these he entered into at considerable length. He advocated the desirability of an inquiry into the amount of food which is necessary for the support of the system.

Geography and Ethnology. (Section E.)

Burton on Dahomey—Spruce on the Purus—Bates on the Amazons—Dr. Livingstone's Communications.

Captain Burton made a very interesting and valuable contribution on the subject of the kingdom of Dahomey. His account is totally different from those hitherto given, but it is distinct and positive. He states the population of the country at less than 150,000, of whom not more than one-fifth are men. The accounts of the profusion of human blood shed on festival days he declares to be a wild exaggeration of a peculiar custom—a mark of filial affection—requiring that all events should be communicated to a dead parent by a human being specially sent to the other world. Thus every extraordinary occurrence demands a murder, in order that the king's father may be duly informed. On stated occasions in the year are larger sacrifices. The whole number of victims, however, even on the occasion of these annual festivals, he estimates at from 35 to 40—a number wonderfully smaller than others have told us, but still horrible enough. All these victims are prisoners and guilty of severe crimes, or are prisoners of war. They are stupefied before being put to death, and the execution is performed in the presence of the king and by his chief ministers.*

* Whilst we give Captain Burton's version of the state of affairs in Dahomey, it is right that we should remind our readers of that of Jules Gérard, who visited the king during a "Grand Custom." His account was communicated to 'The Times,' and to these pages (No. I., p. 209), and he appears to think that when

Capt. Burton states that there is a dual king in Dahomey, one for the town and another for the country; and two courts, one male and the other female. The female element is strong in everything. Not only are there Amazonian troops, but to each important person, even including the English strangers, two women are appointed as guards, under the designation of "mother." The women are unusually strong and muscular, and are organized after a very imperfect fashion into troops. Of these there are four corps, distinguished as grenadiers, elephant hunters, razor bearers, archeresses; and there are also troops of the line, who however do not seem so much given to fighting as to dancing, in which all are great proficients. The total strength of this female army does not exceed 2,500, and the fighting members are not 1,700; of whom 1,000 form the king's body-guard. Strangers—Capt. Burton himself included—are appointed to honorary commands in this singular female army.

In conclusion, and after giving many curious accounts of these people, Capt. Burton expressed his firm conviction that the kingdom of Dahomey, once comparatively strong, is now weakening rapidly, and stated that on the occasion of an attack recently made by them on a neighbouring and somewhat more civilized tribe, they were thoroughly defeated and driven back with little difficulty.

Two papers on the Amazons were read—one by Mr. R. Spruce, on the river Purus; the other by Mr. Bates, on the Delta of the Amazons. The Purus connects with the Amazons near the sea, the water occasionally running from the Purus into the Amazons, and at other times from the Amazons into the Purus. The latter is an important navigable river, running through a country almost a dead level. It has numerous lakes. It comes in from the south, and appears to have deep water, so that it may afford a valuable means of communication with the Andes.

The Delta of the Amazons is exceptional. It is neither a mud swamp nor unhealthy, the soil being sandy, with a rocky substratum of calcareous beds, containing fossil marine shells. The climate is pleasant. In the wet season (January to June), the rainfall in 1848 was 61 inches; and in the dry season (the rest of the year), 9½ inches. There are two low islands within the main mouth of the river, and these also are not muddy. Advancing, however, up the river by the Para branch, all signs of ancient land disappear, and the true Delta may be said to commence. Innumerable labyrinthine channels extend for a distance of 80 miles in length and breadth, and the land consists entirely of recent river detritus. Lofty and luxuriant tropical forest covers every part, and overhangs the narrow channels of water which are often not more than 80 yards wide. The climate here is much more humid than below. It results that (owing no doubt to changes

Englishmen are present the black king tries to make things as pleasant as possible, in order that the scenes enacted may be painted, as they have evidently been, *couleur de rose*. Gérard was driven out of Dahomey for his candour, so if the wretched king of this unfortunate people continues his horrible "customs," it is not for want of knowing those of civilized nations, for they evidently take in 'The Times' at Abomey!—*The Editors.*

of level), a great alteration has taken place in comparatively recent times. Mr. Bates concludes that the mouth of the Amazons was not formerly a wide gulf, filled up since by fluvial deposit, but that it was bridged over by a chain of islands, separated by narrower channels than at present. This is illustrated by the fauna and flora.

An interesting memoir was communicated by Mr. James Fox Wilson, on the desiccation of the interior of Southern Africa, by the gradual drying up of large tracts of country in the Bechuana country. In this district the natives are cutting down all the trees, and burning the dried trailing plants, allowing the fires to extend to the mountains. In other parts, the settlers burn the herbage in winter, to have fresh pasture in spring. The effect of this laying bare the surface, is to increase the drought, and the country will become seriously injured by consequent change of climate. It was generally agreed in a discussion which followed the reading of the paper, that in all civilized countries the supply of rain has long been diminishing, and that this is mainly due to agricultural operations.

Dr. Livingstone's and other communications must be deferred; we cannot do them justice here.

Mechanical Science. (Section G.)

Sorby on Photographing the Structure of Metals. — Selwyn and Fairbairn on Submarine Telegraphy.

Mr. Sorby exhibited photographs taken by Mr. Hoole, of Sheffield, under his superintendence, illustrating the condition of iron and steel. The photographs were taken direct from the microscope. The objects are largely magnified, and the results extremely satisfactory. The metal was prepared by Mr. Sorby by acting on a polished surface with weak acid in a way already known, but the result now obtained is quite new and highly instructive. Among other conditions of iron we have: (1) *Meteoric Iron*, exhibiting its crystalline nature in the most perfect manner. (2) *Grey Pig*. Here crystals of graphitic carbon are seen shooting through the mottled surface of the metal. (3) *Refined Cast-iron*. Long lines of hard parts of the metal (probably spiegel-eisen) have arranged themselves in layers. (4) *Slightly-hammered Bloom*. The imperfect and confused state of the iron and slag irregularly mixed are strikingly shown. (5) *Bowling Bar-iron*. In this, the slag being driven off, and the metal rendered more compact, the texture is seen. The result is very curious and valuable, and contrasts singularly with (6) *Swedish Iron*—a steel-like substance, quite as different in texture as in its properties. (7) *Armour-plate* is a curious variety of No. 5. (8) *Blister-steel*. The effect of the converting furnace is very singular and unexpected, and is well seen in this photograph; while (9) *Cast-steel* shows the total change produced by an even mottled state of the metal, and the general uniformity of the sections of crystals cut transversely.

XUM

No iron-master nor engineer can afford to be ignorant of this simple and effectual mode of determining the structure and texture of the metal he has to do with.

Two papers were read on Submarine Telegraphy—one by Captain Selwyn, R.N., and the other by Mr. Fairbairn, the latter referring to the mechanical properties of telegraphic cables. Captain Selwyn urged that the ordinary cable defended by a spiral wire was weak in principle, as the first strain must be borne by the straight conducting-wire which alone requires defence. He also pointed out that a line to America might take advantage of a shoal in 38° 50′ W. long. in the direct great circle track between England and Bermuda, thus dividing the cable into two sections. Lastly, he recommended that in place of winding the cable as at present, so as to be packed in a ship's hold, it should be wound on one or more closed cylindrical drums acting as floats, and large enough to carry the whole weight. Such cylinders need not be larger than an ordinary canal barge, and could be towed by a steamer, unwound when convenient, and left floating in case of storm. They would be perfectly independent and much cheaper, as well as safer, than the method hitherto adopted. Captain Selwyn proposed for the Atlantic cable a cylinder 120 feet long by 90 feet diameter, which would carry 22,000 tons. The whole weight of the present Atlantic cable is about 6,000 tons.

Mr. Fairbairn's experiments are more fully described at p. 624 of this Journal, than they were before the Association.

NOTES AND CORRESPONDENCE.

Additional Note on the Neanderthal Skull. By Wm. Turner, M.B. (London), F.R.S.E.

In the April number of this Journal I discussed the anatomical characters of the now well-known Neanderthal skull, and advanced a number of examples of modern British crania, which in the extent of their supra-orbital projection, in the retreating nature of their frontal and diminished convexity of their occipital regions, presented forms closely comparable to that of the Neanderthal calvarium. Since the publication of that article I have received a calvarium of a very remarkable form, which may serve as an additional and striking illustration of the occasional appearance in European crania of no great antiquity of characters not unlike those of the skull from the Neander valley. I am indebted for this specimen to the liberality of Dr. Arthur Mitchell, Assistant-Commissioner of Lunacy in Scotland, who informs me "that it was found many years ago, while digging the foundations of Gordon's Hospital in Aberdeen, and that it was regarded, prized, and preserved from its peculiar form, but from the years which have elapsed since it was dug up, from the death of the finder, and the various hands into which it had subsequently passed, it is difficult to trace the exact conditions under which it was found."

I have since ascertained that Gordon's Hospital is built on the site of the Blackfriars Monastery, with which an extensive burial-ground seems to have been connected. It is probable, therefore, that the skull was obtained from a grave in this monastic necropolis. The calvarium is that of a male advanced in years. The sutures are ossified, the denticulations of the sagittal and lambdoidal are quite obliterated. The texture of the bones is very slightly affected; in the posterior part of the skull externally the diploë is partly exposed; but in the anterior part externally, and the whole of the inner aspect, the surfaces of the two tables are smooth. The animal matter is not removed. The bones are of average thickness.

From the accompanying profile sketch of this calvarium (Fig. 1), on which the outline of the Neanderthal skull has been represented by the dotted line, a comparison of the two may be instituted. The supra-orbital projection, due to the size of the frontal sinuses and the retreating forehead, are both well marked in the one from Aberdeen, though scarcely so pronounced as in the Neanderthal specimen. The vertical diameter is, however, greater, so that the former has not so flattened a form at the vertex as the latter. But in both crania the parieto-occipital regions slope downwards from the vertex, and the posterior parts of the parietal bones form an almost continuous curve with the squamous part of the occipital above the protuberance and superior curved line. And in this its occipital form the Aberdeen skull approaches much more closely to the Neanderthal than does the old Batavian from the Island of Marken, cited by Professor Schaaffhausen, as presenting a great resemblance to it. For as Mr. Huxley has pointed out ('Natural History Review,' July, 1864, p. 439), "if the glabello-occipital lines of the Dutch and Neanderthal specimens be made to coincide, the occiput of the former projects backwards beyond the superior curved

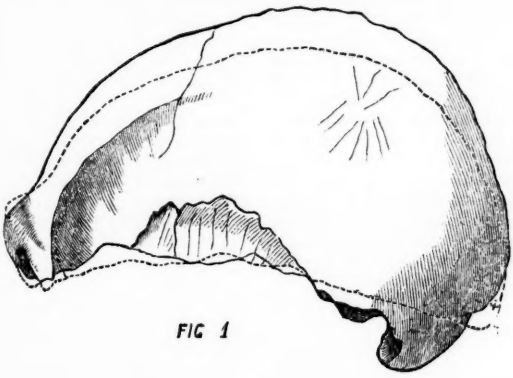


FIG 1

line, whilst that of the Neanderthal slopes upwards and forwards from it."

In the cast of the interior of the Aberdeen calvarium many of the anatomical characters are well dis-

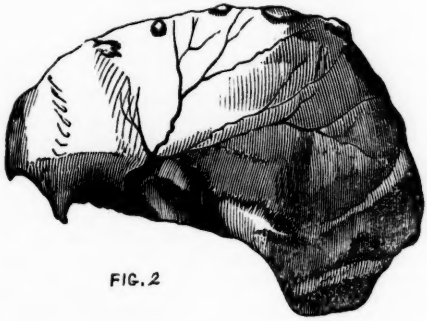


FIG. 2

played (Fig. 2). The comparatively low frontal lobes of the brain, the elevation of the vertex, and the slight posterior convexity of the occipital portion of the cerebrum, are all apparent. It may be noted that the posterior lobes of the cerebrum overlap the posterior margin of the cerebellum, though in the figure the extent of this overlapping is somewhat exaggerated, on account of a Pacchionian body projecting from the dura mater just above the attachment of the tentorium.

	Inches.
Greatest length of the Aberdeen skull	7·7
Greatest breadth in the parietal region just above the squamous suture .	5·9
Proportion of length to breadth	100·76
Length of the line of the sagittal suture . . .	4·9
Longitudinal arc . . .	12·6
Horizontal circumference .	22·0
Greatest frontal breadth .	4·5

Capacity of calvarium, 80 cub. in.

In conclusion, I may state that on p. 227 of Sir Wm. Wilde's book, 'On the Beauties of the Boyne and Blackwater,' a skull is figured and described as long and low, which, so far as can be judged from the outline sketch, presents in combination characters which closely approximate it to the Neanderthal cranium. The skeleton of which this skull formed a part was found in 1821, in a gravel-pit in the Island of Funen. Along with it were various metallic articles, a silver buckle, a spirally-twisted gold ring, and a large metal pan or kettle.

Also, in the 'Reader' newspaper, 23rd July, 1864, Mr. Busk states that he has received from Captain Brome, of Gibraltar, a human cranium which resembles, in all essential particulars, including its great thickness, the Neanderthal skull. From the conditions under which it was found, Mr. Busk ascribes enormous antiquity to it.

WM. TURNER.

On the Septa and Siphuncles of Cephalopod Shells. By Harry Seeley, F.G.S., Woodwardian Museum, Cambridge.

THE last generation of anatomists shelved the question of the significance of septa in Nautiloid shells, by assuming that the air-chambers were a beneficent provision for enabling the animals to float. But though the specific gravity of the mass is thus altered, that does not explain the *physiological* meaning of the septa.

As the shells enlarge, the animals increase in size, and, with seldom-varying regularity, shut off behind them chambers which steadily enlarge with the whorls. Only near the end of the series are the cells less uniform, where in the adult the last one is conspicuously shallow. And as the chambers are always empty, the animal must have moved forward, leaving a vacant space behind; so the question to be solved is, why did the creature always make the septa shut off spaces which progressively enlarged?

In certain Gasteropod shells there is something analogous. The genera Murex, Triton, Ranella, for instance, after making their shells uniformly for a third or half of a whorl, then begin thickening the lip into a varix —rarely with the least want of regularity. In other genera, as Bulimus, Conus, Turritella, species or specimens are found with the earlier part of the spire partitioned off. The same phenomena of varices is seen in many bivalves; and a process of shutting off air-cells in the lower valve is characteristic of several oysters.

As the shell of an animal is moulded on its body, I suppose these cells in the abdominal part of an oyster-shell to indicate that the animal gets periodically larger and then smaller. Covering the visceral region are the white parts of the mollusc, the ovaries, and these periodically thicken the body; the lips then in enlarging the shell will make it more concave, and when the ovaries are empty there will remain a vacancy under the ovary like a water-cell, which the abundant nacreous secretion soon shuts off. Moreover, the ovaries are the exterior parts of the organism adjacent to the shell.

In Gasteropods, as the upper part of the spire contains the liver, similar results cannot be looked for in their reproduction; but the ovaries being placed in the middle of the body, and provided with oviducts, often of great size, an enlargement of the whorl must take place by growth at the lip of the mouth till the mollusc attains its full size. And that this is not merely needed to accommodate the body of the animal may, I think, be seen by noticing how far Helices which have laid their eggs retire from the

mouths of their shells. And the varices of shells appear to be owing to a cessation of reproductive enlargement in the animal, and hence the mantle accumulates its secretion in a thickening at the lip.

Now, on examining a nautilus-shell, two large muscles are seen to have been placed in the lower part of the body-chamber, and connected round the involute spire by a narrower muscle; an arrangement to which the shell may owe its involute form. Beneath the muscles are the liver which overlaps the spire, the ovaries which abut on a large part of the septum, and certain digestive organs above these. Before any new chamber can be made, the shell-muscles must have moved forward; and before any increase in the ovaries can take place, a space must be formed behind. As the animal steadily grows, all its organs would enlarge, and with each successive brood the distended ovaries would require more space. There is a similar gradual increase in the size of the air-chambers. And since the development of ova would necessitate a forward growth of the mollusc, the discharge of the ovaries would leave an empty space behind, into which the creature could not retire, which would then be shut off by a septum moulded on the animal's body; and it may be worth notice that at the place of the flaccid ovaries, both at the sides and outer part of the shell, the septum extends far forward.

The Argonaut similarly accumulates its eggs in the involute part of the shell, but not being attached to it, does not form septa.

In the male nautilus the testes are placed in exactly the same position as the ovaries of the female, and, excepting the liver, are the largest organ in the body. It may therefore be concluded that the development of the male organs would produce results similar to those in the other sex, and likewise end in the formation of chambers.

There are no other organs of the body which are liable to periodic changes in size; and therefore as the position and progressive enlargement with age of the generative apparatus necessitate results like those seen in the chambers and septa, I regard one as the cause of the other.

If this is the significance of septa in the nautilus, the same must be said of all nautiloid shells, and the families of Ammonites and Orthoceratites; and as the structure of the phragmacone of Belemnites is essentially similar, it must also be applied to such debranchiate shells as are chambered. Among these is the Spirula, connected with a shell essentially like a nautilus shell. Professor Owen describes the greater part of the animal as in front of a shell that is enclosed by a protecting lappet on each side, which is regarded as an ovary. Though this is different from the arrangement in the nautilus there need be no discordancy, for as the animal is not contained within, but overgrows its shell, so ovaries would be expected to extend beyond the rudimentary shell; but from the defect of specimens, I can offer nothing but analogy on behalf of the homology of the two sets of chambers.

In the sepia the ink-bag and ovaries are placed at the end of the animal's body just in front of the mucro of the shell; and in the Belemite the ink-bag is found just above the phragmacone.

Connecting the chambers is the tube known as the *siphuncle* running through every septum to the first, but not through the nidamental capsule. In the nautilus it is often but partly calcified; it changes its position in different genera; and in some fossil-forms, as the sub-genera of Orthoceras, is large and complicated, being sometimes radiated like a coral, and perforated by an inner tube.

Seeing the extreme elasticity of many membranes of invertebrata, as, for instance, the oral membrane of a starfish, I would also point

out that when ova were discharged by the nautilus there must have remained the empty membrane, which being attached to the base could not but contract into a tube smaller or larger according to its tenuity or vascularity. The fine siphuncle of the nautilus would indicate a single highly contractile membrane; the large siphuncle of Actinoceras may indicate two or three membranes contracting differently.

And the conclusion from these considerations is that the chief fossil genera of cephalopods are based on slight modifications of the reproductive apparatus, which have produced, in their many beautiful and complex variations, the septa siphuncles of the Nautilus and its allies.

HARRY SEELEY, F.G.S.

On the Existence of the Reindeer and Aurochs in France during the Historic Period. By the Rev. C. W. Kett, M.A.

IN some remarks upon flints and carved bones and horns found in the grottos of Périgord, in the number of 'The Quarterly Journal of Science' for July, p. 579, these implements are stated to prove the existence of the reindeer in the centre of France in *prehistoric* times, and from the carving on them to give the impression that aurochs also existed then in the same country. Your correspondent does not seem to be aware that both these animals existed in *historic* times; that Cæsar describes an animal which has been taken by scholars to represent the reindeer, and that he mentions the aurochs * (*urus*) by name. The description of Cæsar certainly shows that he had never seen these animals, but that he had gathered his information from others; in fact he brings forward this description in a part of his work in which he contrasts what he has heard of the different nations of the Gauls and Germans. I cannot think, however, that this entirely invalidates his testimony, as he appears to have seen the horns and heard of the hunting exploits of the young Gauls of his day. Thinking your readers may be interested in Cæsar's own description, I annex a translation of the two chapters alluded to, 'De Bello Gallico,' lib. vi. cc. 26, 28.

* German *Auer-ochs*, heath or wild ox.

"There is an ox (*bos*) with the form of a stag, and from the middle of its forehead between the ears one horn stands up, higher and straighter than those horns which are known to us. From the end of it branches like palms (*palmæ*) spread out very widely. The male and female are alike, and the shape and size of their horns the same."—CÆSAR: *De Bell. Gall.* lib. vi. c. 26.

"The third is a kind of them which are called aurochs (*uri*). These are of a size little less than elephants; in appearance, colour, and form they are bulls (*tauri*). Their strength is great and so is their pace, and, when they have seen them, they spare neither man nor beast. A good deal of trouble is taken to catch and kill these in pitfalls. In this work the young men harden themselves, and they exercise themselves in this kind of hunting, and those who kill most of them bring their horns as a public testimony, and in this way obtain much honour. Even if they catch them very young, they cannot accustom them to man or make them toward. The size, form, and appearance of their horns differ a good deal from our oxen. They are very careful to tip the lips with silver, and then they use them at their grand feasts."—CÆS.: *De Bell. Gall.* lib. vi. c. 28.

The word *bos*, here translated "ox," is used of all kinds of horned

animals, and even for elephants. *Palmæ* has been variously translated, the palms of the hand, the branches of the palm-tree, and the blades of oars. But whatever explanation we put upon these words, the whole description has usually been referred to the reindeer, and has been so understood by Cuvier, Buffon, and Beckman. The single horn, of course, is a mistake, though one that is common enough. Some writers still assert that there is good evidence of the existence of unicorns in the centre of Africa, and although we will not say that such things cannot exist (having the fear of the author of the 'Water Babies' before our eyes), still Cæsar is as likely to have been mistaken in this matter as in the assertion he makes in the following chapter, that the elk cannot bend its legs or get up when once thrown down, whilst he is true as regards the main facts of existence of the animals in France in historic times.

C. W. KETT.

THE GOLD MEDALLISTS OF THE SCIENCE EXAMINATIONS, MAY, 1864, AND SCIENCE INSTRUCTION BY THE STATE.

WE have great pleasure in publishing, as conspicuously as we are able, the names of those Students of the Classes who, to their honour, succeeded in obtaining the Gold Medals at the recent (May) examinations of the Science and Art Department. The names in italics are those of Middle Class Students who obtain Honorary Certificates instead of Medals.

Name of Gold Metallist.	Age.	Residence.	Subject.	Teacher.
JOHN B. BAKER	18	Chester	Geometry, Mechanical Drawing, and Building Construction.	E. A. Davidson.
EDWARD RICHARDS	19	London	Theoretical and Applied Mechanics.	R. Straughan.
JOHN G. ANDERTON	20	Birmingham	Acoustics, Light, Heat, Magnetism, and Electricity.	C. J. Woodward.
John W. Judd	24	*London*	*Ditto ditto*	*Self-taught.*
WILLIAM BARR	19	Glasgow	Inorganic and Organic Chemistry.	Dr. F. Penny.
Alfred H. Allen	18	*Sheffield*	*Ditto ditto*	*Self-taught.*
JOHN CONNOLLY	22	Cork Road, Bandon.	Geology and Mineralogy	Self-taught.
John W. Judd	24	*London*	*Ditto ditto*	*Ditto.*
HENRY ANGEL	20	Islington	Animal Physiology and Zoology.	J. Howard.
ISABELLA MAFFETT	22	Belfast	Vegetable Physiology, Economic and Systematic Botany.	R. Tate.
John W. Judd	24	*London*	*Ditto ditto*	*Self-taught.*
George J. Snelus	26	*Macclesfield*	*Physical Geography*	*— Hewitt.*

The Department of Science and Art also grants Silver and Bronze

"Queen's Medals," (as these rewards are termed,) to successful competitors at the Annual Examinations; but, for the names of these, we must refer our readers to the published Report of the Department.

From the last Report it appears that the number of Science Classes, Teachers, and Students is on the increase, and it was our intention to devote an article in our present number to the question of the extension of Science instruction as it is undertaken by the State—to the relations, in fact, of the Department of Science and Art to the community at large.

The Report has, however, been so recently issued, and so many grave questions are involved, that we must for the present defer the consideration of the subject.

We hope, however, shortly to be able to deal with the matter in an impartial spirit, and all communications which we may receive from Science Teachers, or the promoters of Science Classes in regard to the working of their Schools, or the operation of the various "Minutes" which have from time to time been issued by the Committee of Council on Education, will receive our earnest consideration. Such communications will enable us to arrive at correct conclusions, and to reflect the opinion of a large body of hard-working-men of Science, who, as far as we know, possess no other suitable medium for the expression of their views on matters connected with their material interests.

Books received for Review.

From *Messrs. Longman & Co.*:—

Sight and Touch: an Attempt to Disprove the Received (or Berkeleian) Theory of Vision. By Thomas K. Abbott, M.A., Fellow and Tutor of Trinity College, Dublin.

The Linen Trade, Ancient and Modern. By Alex. J. Warden, Merchant, Dundee.

Passages from the Life of a Philosopher. By Charles Babbage, M.A., F.R.S.

On the Application of Cast and Wrought Iron to Building Purposes. By William Fairbairn, C.E., F.R.S, F.G.S. 3rd edition. To which is added, A Short Treatise on Wrought-Iron Bridges.

From *Messrs. Trübner & Co.*:—

Organic Philosophy; or, Man's True Place in Nature. Vol. I. Epicosmology. By Hugh Doherty, M.D.

From *Messrs. Lockwood & Co.*:—

A Series of Metric Tables, in which the British Standard Measures and Weights are compared with those of the Metric System at present in use on the Continent. By Charles Hutton Dowling, C.E.

From *Messrs. Simpkin, Marshall, & Co.*:—

General and Concise History and Description of the Town and Port of Kingston-upon-Hull. By James Joseph Sheahan, Author of Histories of Cambridgeshire, Oxfordshire, &c. &c. &c.

From *the Authors*:—

Rambles in Search of Flowerless Plants. By Margaret Plues. ('Journal of Horticulture' Office; and Houlston & Wright.)

Rhopalocera Africæ Australis. A Catalogue of South African Butterflies; comprising Descriptions of all the Known Species, with Notices of their Larvæ, Pupæ, Localities, &c. &c. By Roland Trimen, Mem. Ent. Soc. London. Part I. Papilionidæ, Pieridæ, Danaidæ, Acræidæ, and Nymphalidæ. (Cape Town: Mathew, George Street.)

Philological Papers, comprising Notes on the Ancient Gothic Language. Parts I. and II. Sanscrit Roots and English Derivations. By J. A. Picton, F.S.A., President of the Liverpool Literary and Phil. Society. Also, A Chapter on the Philology of Architectural Terms. (Liverpool: Brakell.) (For private distribution only.)

The Study of the Physical Sciences: their Value in Education, and the Part they play in advancing the Civilization of Mankind. An Essay. By George D. Wood. (London: F. W. Calder.)

PAMPHLETS, REPRINTS, LECTURES, ADDRESSES, &c.

On the Microscopical Structure of the Mount Sorrel Syenite. By H. C. Sorby, F.R.S., F.G.S.

On the Chronological Value of the New Red Sandstone System of Devonshire. By W. Pengelly, F.R.S., &c.

Elementary Inquiry into the Laws of the Conduction of Heat on Bars, and into the Conducting Power of Wrought Iron. By James D. Forbes, LL.D., D.C.L., F.R.S., &c.

On Vitality. (Read before the Liverpool Literary and Philosophical Society.) Rev. H. H. Higgins, M.A.

On the Electrical Relations of Metals, &c., in Fused Substances. By G. Gore.

Experiments on the Adhesion of Liquids to Mercury. Same author.

On the Properties of Electro-deposited Antimony. Same author.

Doubts relative to the Epochal and Detrital Theory of Geology. By a near Kinsman of Thomas Didymus. (No publisher.)

The Truth of the Bible Upheld; or, Truth versus Science. By L. S. Benson, South Carolina. (Saunders, Otley, & Co.)

The Abbeville Jaw. An Episode in a Great Controversy. By J. L. Rome, F.G.S. (Longmans.)

A New System of Musical Gymnastics. By M. C. Taylor, M.A., M.C.P. (Tweedie.)

On the Wave of High Water; with Hints towards a New Theory of the Tides. By Thomas Carrick. (Taylor & Francis.)

Mémoire des Professeurs-Administrateurs du Muséum d'Histoire Naturelle, en réponse au Rapport fait en 1858, par une Commission chargée d'étudier l'organisation de cet établissement. (Paris: Mallet-Bachelier.)

Kew and Lisbon Magnetic Curves. Photolithographic impressions of Traces produced simultaneously by the self-recording Magnetographs at Kew and Lisbon. (With explanatory circular.)

L'Hiver dans le Midi: Indications climatologiques et médicales, et Conseils aux Malades. Par A. Buttura, M.D. Paris, &c. &c. &c. (London: Hipp. Baillière.)

The Sanitary Duties of Private Individuals. (The Ladies' Sanitary Association.)

Lumley's Patent Rudder: Descriptive Particulars, &c.

PERIODICALS, AND PROCEEDINGS OF SCIENTIFIC SOCIETIES.

Journal of the Asiatic Society of Bengal. No. 293. (Calcutta.)

Journal of the Chemical Society. (Baillière.)

Bulletin Mensuel de la Société Impériale Zoologique d'Acclimatation. (Paris: Masson.)

Memoirs of the Geological Survey of Great Britain, and of the Museum of Practical Geology. By Robert Hunt, F.R.S., Keeper of the Mining Records. (London: Longmans; and Stanford.)

Transactions of the Woolhope Naturalists' Field Club. President's Address, The Mistletoe, Earthquake of 1863, and Meteorological Report. (Hereford: Head.)

The Geological Magazine (with which is incorporated the 'Geologist'). Edited by T. Rupert Jones, F.G.S., assisted by Henry Woodward, F.G.S., F.L.S.

Revue Universelle des Mines, de la Métallurgie, &c., &c. (Paris & Liège: Noblet & Baudry.)

Jenaische Zeitschrift für Medecin und Naturwissenschaft. (Published by the Natural History Society of Jena.) (Leipzig: Engelmann.)

The Mining and Smelting Magazine. (At the Office, 36, Cannon Street; and Simpkins.)

The British and Foreign Medico-Chirurgical Review. (Churchill & Sons.)

Report of the Superintendent of the United States Coast Survey during the Year 1861. (From the Superintendent.)

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